

APPLICATION OF ERTS-1 DATA
TO THE PROTECTION AND MANAGEMENT OF NEW JERSEY'S
COASTAL ENVIRONMENT

ESC-304

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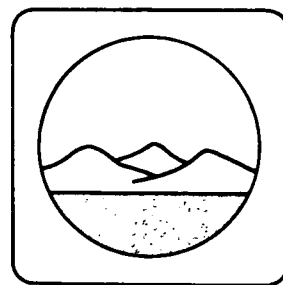
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COASTAL ZONE SURVEILLANCE PROGRAM

**INFORMATION PRODUCTS PREPARED FROM ANALYSIS OF
EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS) DATA**

**FOR THE NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION**



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PREFACE

The primary objective of this ERTS-1 experiment is to develop useful information products from analysis of imaged coastal land and marine resources and to apply these products to practical regulation, protection and management of New Jersey's coastal zone.

Analysis of ERTS imagery and complementary aerial photography has led to the development of seventeen information products that are being used within the Department of Environmental Protection as new sources of information for coastal zone management.

Problem areas of significance to the State, and in which product development has centered, have been identified as: the environmental effects of offshore waste disposal, the placement of ocean outfalls, the better understanding of littoral processes for shore protection, the delineation of the coastal ecozones, and the determination of flushing characteristics of the State's estuaries. Of equal importance has been the development of a capability within the State to use and understand remote sensor-derived information, and the application of products to meet the requirements of current and anticipated coastal zone legislation.

All of the seventeen products developed to date have been directed towards meeting the above mentioned problem areas and/or objectives.

These products are presently being used within the NJDEP for coastal zone management.

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TYPE II REPORT

APPLICATION OF ERTS-1 DATA
TO THE PROTECTION AND MANAGEMENT
OF NEW JERSEY'S COASTAL ENVIRONMENT

1.0 INTRODUCTION

1.1 General

This document is the second Type II Report submitted in association with NASA Contract Number NAS5-21765.

The primary objective of this experiment is to develop useful information products from analysis of imaged coastal land and marine resources and to apply these products to the regulation, protection, and management of New Jersey's coastal zone.

A secondary objective has been to develop a capability within the New Jersey Department of Environmental Protection (NJDEP) to utilize remote sensor-derived data.

Analysis of ERTS-1 imagery and aircraft underflights and the subsequent development of information products has shown that repetitive imaging of the coastal zone environment along the New Jersey shore can provide varying levels of useful information which will contribute to coastal management decision-making within NJDEP. ^{1/}

^{1/} A cover letter is being prepared by the State to describe the utility of ERTS for various operational State problems.

This Type II progress report describes the analysis of imagery to date and the development of remote sensor-derived information products that are being distributed and used within the State.

1.2 Summary of Accomplishments

The principal accomplishments and significant results during this reporting period are discussed below. Many of these accomplishments have been developed into user-oriented products (▶).

- ▶ • An ERTS photomap of New Jersey's Coastal Area was prepared for NJDEP use and was instrumental in the passage of new coastal legislation, "The Coastal Area Facility Review Act".
- ▶ • An Outfall Planning Map has been prepared which illustrates nearshore circulation, as analyzed from seventeen orbits of ERTS-1, supplementary aircraft photography, and historical records. Data analysis indicates a predominant north-south flow along the New Jersey coast except at points near tidal inlets where a rotary flow can be expected.
- ▶ • A shore protection information product has been prepared which shows a comparison of beach ownership vs. erosional characteristics vs. dollars requested for shore protection in fiscal year 1972.
- ▶ • An Offshore Waste Disposal Map for the New York Bight area is routinely prepared for each orbit. ERTS monitoring will be used by NJDEP to facilitate coastal water quality sampling, and to assess the merits of future litigation or complaints related to coastal pollution.

- ▶ • An Upper Wetlands Boundary Map at 1:500,000 scale has been prepared for coastal New Jersey using the ERTS-1 color composites and MSS Band 7. If routinely prepared, it may contribute to further implementation of the Wetlands Act of 1970 in coming years.
- ▶ • Systematic comparisons of early ERTS images and recently acquired images are regularly made to identify areas where changes have occurred. These changes are reported to NJDEP for field checking in compliance with New Jersey's Wetlands Act and their new Coastal Area Facility Review Act.
- ▶ • An ecozone map for the entire State has been prepared using ERTS-1 MSS Band 5 as the basemap. Fifteen ecozones are categorized by homogeneous interrelationships of soils, landforms, vegetation, geology, drainage, and land use.
- ▶ • Two New Jersey ERTS-1 Investigators' Basemaps (North and South) at 1:250,000 scale have been prepared for NJDEP personnel. An Investigators' Basemap at 1:500,000 scale has also been prepared. As the program proceeds, information will be presented on clear acetate overlays and routinely delivered to the appropriate NJDEP offices.
- ▶ • A color mosaic of the entire State has been prepared at 1:1,000,000 scale. This has been enlarged to a 1:500,000 scale for printing. The mosaic is used in land resource analysis for the coastal zone.

- ▶ • ERTS imagery narrative analysis forms are filled out as each image set is received. These forms will later serve the State.
- ▶ • ERTS imagery in conjunction with nineteen years of low-level photography has been analyzed for nearshore circulation in an attempt to forecast ocean outfall dispersion directions and hence to control pollution. More than 50% of the time, the surface flow is onshore. Ocean outfall surface plumes of up to 4,500 feet in length have been measured using supplementary aircraft data.
- Offshore waste disposal analysis indicates a predominantly southwest drift of material in the surface waters. Dumps have been imaged in areas as large as 32 square miles, whereas designated dumping sites are 4 square miles in area.
- A water mass boundary, associated with the Hudson River - New York Harbor discharge plume is repetitively observed along the New Jersey coast and has consistently extended as far south as Long Branch-Deal, New Jersey.
- Analysis of all imagery to date indicates a fairly consistent, wide band of turbid water extending offshore 5-7 miles. There is considerable streaking in this water mass which is formed primarily by tidal discharges from inlets and the New York Harbor discharge.

- The waters of the estuaries, bays, sounds, thoroughfares, etc. in southern New Jersey are much more turbid than the waters in the northern part of the State. This corresponds to the practice of discharging domestic sewage and industrial wastes into the back-bay waters in southern New Jersey, whereas these wastes are discharged offshore in the north.
- One of the largest remote sensing experiments ever attempted in this country was completed on April 7, 1973 during an ERTS-1 overpass. The test area included the northern portion of New Jersey and the Raritan Bay-New York Harbor area. Three NASA aircraft, two helicopters, nine surface vessel (six of which were coordinated through the NJDEP Marine Police), 40 ground team personnel, and numerous oceanographic, radio-metric and meteorological equipment were deployed in an effort to characterize the surface and near-surface circulation dynamics in this 600 square mile area, during an entire tidal cycle.
- The Final Report Outline has been revised and updated.
- The Data Analysis Plan was submitted to the ERTS Contracting Officer.
- ▶ • A First Look Data Analysis Report was prepared for NJDEP which included the analysis techniques used and the principal results of the Pre-Launch and First-Look Phases of this investigation.

- ▶ • A paper was prepared and presented for the ERTS-1 Symposium on Significant Results, March 5-9, 1973.
- A methodology for assessing and documenting benefits has been established. The quantification of benefits will be directed to four candidate areas: shore protection, ocean outfalls, navigation channels, and offshore waste disposal.

2.0 ANALYTICAL PROCEDURES AND TECHNIQUES

2.1 Initial Analysis

As of this reporting date, all in-house imagery has undergone initial analyses for information content. An initial evaluation of the imagery has been conducted as each ERTS-1 image set was received, with particular emphasis on the following characteristics, processes, and phenomena:

- cloud cover and haze level
- discolored (sediment-laden) current plumes
- changing morphology of sub-aerial and submergent coastal landforms
- nearshore waste disposal
- shoreline construction projects
- dredging and filling
- wetland delineations
- nearshore current indicators
- coastal development
- anomalous features

All recognized features impacting on the coastal environment have been annotated during this initial analysis indexing. This initial image annotation procedure provides a means of referencing, by environmental phenomena, data that is useful for future analysis of successive image sets. These narrative analyses are recorded on an EarthSat form (New Jersey ERTS-1 Image Analysis Form). A set of these data can be found in Appendix A.

2.2 Relative Interpretability of MSS Bands

EarthSat has received each type of image product made available to ERTS-1 investigators. The 70mm transparencies provide the best detail and the most information. The color composites are useful in a comparative analysis in conjunction with individual 70mm transparencies for each band. It was hoped that the 9.5" X 9.5" precision processed transparencies would provide more information than the bulk processed imagery but this has not been the case. The precision processed images are often of poor quality and have been of limited value to date.

The relative interpretability of the four MSS bands has been assessed as follows. These conclusions were reached after comparative study of the same features on each image. The number scale represents (1) as being the best and (4) as providing the least information.

<u>Feature/Problem</u>	<u>4(.5-.6μm.)</u>	<u>5(.6-.7μm.)</u>	<u>6(.7-.8μm.)</u>	<u>7(.8-1.1μm.)</u>
land-water interface	4	3	2	1
wetland-upland interface	3	1	3	2
land patterns	2	1	4	3
coastal current patterns	2	1	3	4
forest types	2	1	2	2
road network	2	1	4	3
urban core detail (N.Y.C.)	4	1	3	2
offshore waste disposal	2	1	3	4
estuarine flushing	2	1	3	4

Where the same rating was given to 2 bands, it was judged that there was no consistent difference in interpretability.

2.3 Photo and Image Reproduction

EarthSat has expanded its photo laboratory processing facilities to accommodate both color and black-and-white processing capabilities. Routine enlargements and contact prints are made from the ERTS transparencies as a regular part of the analysis cycle. Various phenomena can best be interpreted at different scales. Photographic enlargements of ERTS-1 images have been produced to allow ready transfer of observable coastal phenomena to existing nautical charts (with scales ranging from 1:40,000 to 1:1,000,000) and/or topographic maps (with scales ranging from 1:24,000 to 1:250,000). A color mosaic of the entire State has been prepared at a scale of 1:1,000,000.

2.4 Background Data

Existing collateral data, e.g. meteorology, hydrography, coastal current records, coastal engineering reports, research papers, waste dumping schedules, outfall design and capacities, etc. have been continually collected during Phases I and II to provide a substantial historic data base. A cross referenced bibliography has been prepared and is on file to assist in the further analysis of ERTS-1 imagery. NASA aerial remote sensing coverage of the test area, along with New Jersey Department of Environmental Protection routine coastal flight photography, has been used in the analysis of ERTS-1 imagery in order to obtain a more detailed assessment of local coastal conditions.

3.0 IMAGE ENHANCEMENT

Numerous optical and electronic devices have been used in the analysis of ERTS-1 imagery. The following is a description of some of the equipments and facilities which have been used in this experiment. Special attention is being given to techniques which may be adopted by Department personnel for routine image analysis.

The I²S Digicol Density Slicing Equipment allows the investigator to identify, measure, and display image density characteristics. With this capability, subtle sediment patterns, pollutant dispersion characteristics, and coastal water mass discontinuities such as offshore waste disposal sites have been enhanced. Given density levels have been directly related to measured turbidity in the estuarine and coastal waters. An attempt has been made to quantify the image densities of the offshore dumping sites to waste dispersion rates, and to the types of waste materials being dumped. However, no definitive correlations have been established up to the present time.

The I²S Addcol Additive Color System has been used for the optical registration and mixing of 4 separate 70mm ERTS-1 single band positives of the same scene on a single viewing screen in color or false color. Wetland vegetation, turbidity variations, and water mass boundaries are often greatly enhanced by this technique. This device has also been used to locate natural and cultural landform changes in coastal areas. ERTS-1 images from two separate orbits are superimposed on the viewing screen, each with a different color filter for projection. If one of the colors

is evident a change has occurred at that site. This technique holds promise as subsequent orbits are obtained and seasonal/yearly changes can be seen.

The Bausch and Lomb Zoom Transfer Scope has been routinely used for transposing estuarine and coastal water detail to appropriate base-maps. As features from sequential orbits are plotted, current movements, sediment dispersion rates, and the geographical extent of wastes are easily interpreted. This instrument is used routinely in the plotting of offshore waste disposal and in the transposing of information to base-maps at 1:250,000 and 1:500,000 scale.

4.0 GROUND TRUTH COLLECTION

The surface truth data acquisition network as originally conceptualized within the NJDEP was not extensive enough to meet the objectives of the experiment. Therefore, attention has been given to coordinating other Federal and University ground truth activities that were taking place along the New Jersey coast. This effort has provided a data base to NJDEP from which more extensive analyses of ERTS-1 imagery is now proceeding.

The general approach to the selection of test sites has changed so as to be more responsive to interdisciplinary needs within the NJDEP. Following interviews with a variety of NJDEP personnel and an assessment of the NJDEP data acquisition network, the concept of fixed test sites has been revised. The sites are chosen as the need arises to respond to the dynamic nature of the environmental and coastal management problems of NJDEP.

4.1 Selected Surface Truth Sampling (Immediate Response)

Coastal areas of primary concern to the State will be sampled to such an extent as needed to determine water quality, physical characteristics, major tidal and wind-driven circulation, and other parameters needed to analyze any problem requiring prompt action, e.g., red tide, major nearshore pollution, severe storm erosion, etc. Surface data collection will be made as concurrent with ERTS-1 overpasses as possible. This will be a continuing effort focused on immediate response reporting related to environmental problems as they occur within the state.

4.2 Major Surface Truth Collection Effort

Due to the complexity of the coastal marine environment and the limited monies allocated for surface truth investigations, the NJDEP and EarthSat took advantage of a major national remote sensing experiment in the New York Bight marine environment during late March - early April 1973. This test area included the northern portion of New Jersey and the New York Harbor - Raritan Bay area. This surface truth collection program involved thirteen separate government and private organizational components including three NASA aircraft which provided ERTS underflights on April 7, 1973. These aircraft provided complete sequential coverage throughout the day during a complete tidal cycle. Small boats (including those of NJDEP) operated along the coastal lines and in Lower, Sandy Hook and Raritan Bays. Larger survey vessels occupied stations in the seaward areas off the New Jersey coast. Helicopters were utilized to implant moored dye point sources prior to the overflights. During the overflights,

the helicopters served as survey platforms and conducted measurements across regions of marked surface discontinuities.

The mission was very successful and all data collection efforts planned were completed. Analysis is underway on the surface truth information, however, no aircraft data has been received during this reporting period.

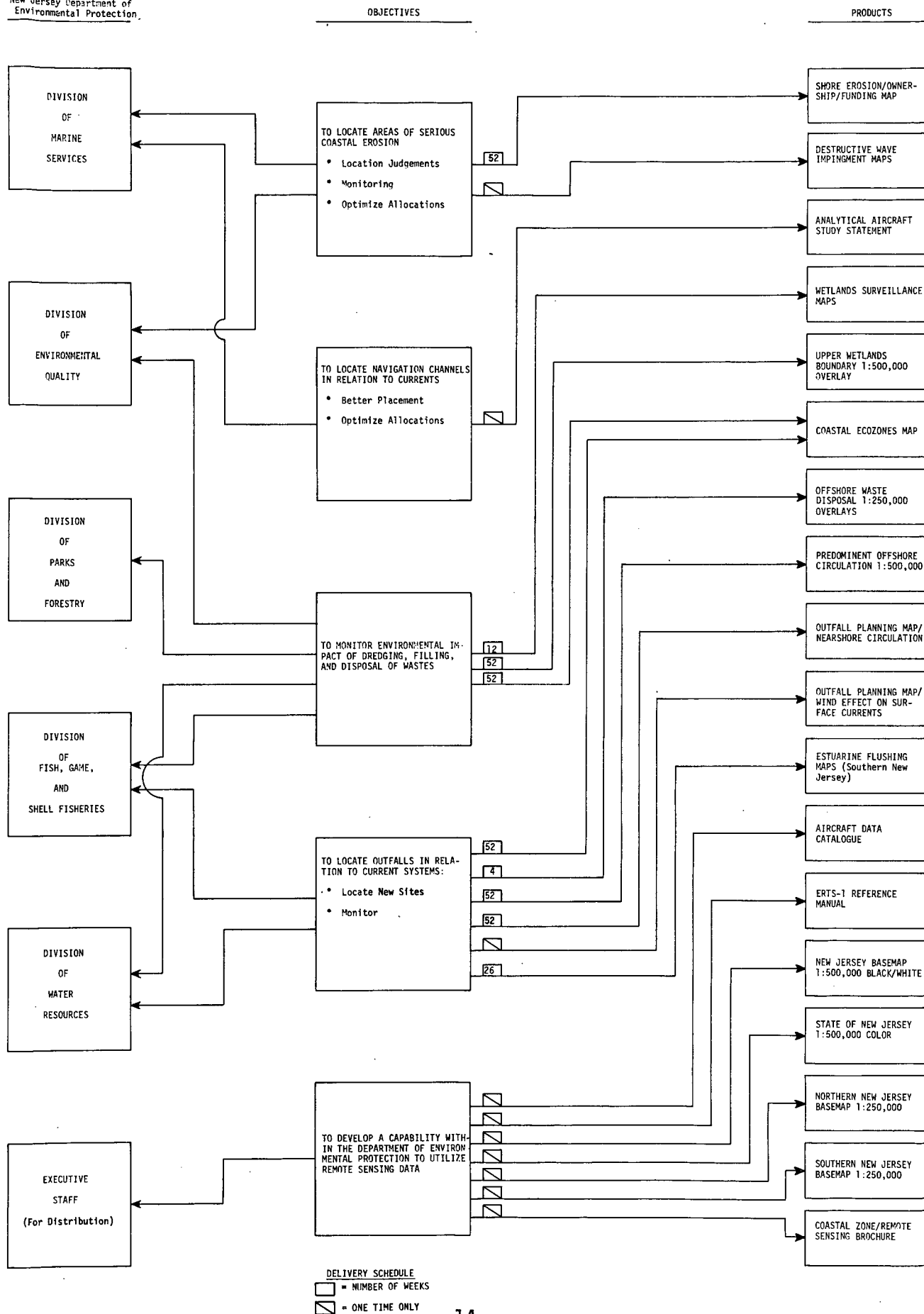
5.0 RESULTS

Contract objectives can be divided into two separate and distinct groups: (1) applications objectives which are directed to using ERTS imagery to solve practical coastal management problems and (2) to develop a capability within NJDEP to use remote sensor derived information. Based on this grouping of objectives, two categories of information products have emerged. Figure 1 lists some of the products developed during the first year of the experiment, their relationship to experimental objectives, and contribution(s) to the various operating Divisions within the NJDEP.

Analysis of ERTS-1 imagery during this reporting period has centered on these five major problem areas of importance to the State.

- OFFSHORE WASTE DISPOSAL
- OCEAN OUTFALL PLACEMENT
- COASTAL ZONE (LAND) RESOURCES
- ESTUARINE FLUSHING DYNAMICS
- SHORE PROTECTION

Figure 1



To develop the capability within the NJDEP to utilize ERTS and aircraft remote sensor data, various approaches of exposure and training are being used. Products developed to provide this basic understanding of remote sensor data and baseline maps upon which new information can be plotted are as follows:

1. Aircraft Coverage Catalogue
2. ERTS-1 Reference Manual
3. New Jersey Basemap 1:500,000 Black/White (Figure 2)
4. Northern New Jersey Basemap 1:250,000 Black/White (Figure 3)
5. Southern New Jersey Basemap 1:250,000 Black/White (Figure 4)
6. State of New Jersey, 1:500,000 color (Figure 5)
7. Coastal Zone Remote Sensing Brochure for County/Municipal Groups (Appendix B)

As briefings and interviews were held within the various divisions and bureaus, numerous operational problems were identified and the need for a suitable base upon which new information could be displayed arose. The above products will serve to standardize the presentation of coastal information derived from ERTS-1 analysis.

5.1 Offshore Waste Disposal

New Jersey occupies a unique position among states in that it borders one of the largest offshore waste disposal sites in the world, the New York Bight. For over 40 years this area has been used as a sink for domestic and industrial wastes without an environmental monitoring program to document and assess both the short and long-term environmental effects. These

Figure 2

NEW JERSEY ERTS-1 INVESTIGATORS BASEMAP

Let's protect our earth



NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

THIS PHOTOMAP PRODUCED FROM A NASA ERTS-1 MOSAIC OF MSS BAND 5 TAKEN ON OCTOBER 9, 1972 HAS BEEN PREPARED FOR DISTRIBUTION WITHIN THE STATE OF NEW JERSEY'S DEPARTMENT OF ENVIRONMENTAL PROTECTION. CLEAR ACETATE OVERLAYS WILL BE PREPARED OF VARIOUS ENVIRONMENTAL PHENOMENA AS ANALYZED AND OBSERVED FROM ERTS-1 IMAGERY AND WILL SUBSEQUENTLY BE DELIVERED TO DEPARTMENT INVESTIGATORS.



5 0 5 10 15 20 Statute Miles

5 0 5 10 15 Nautical Miles

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Washington, D.C. 20006



Figure 3

NEW JERSEY ERTS-1 INVESTIGATORS BASEMAP NORTHERN SECTION



Let's protect our earth



**NEW JERSEY
DEPARTMENT
OF ENVIRONMENTAL
PROTECTION**

PHOTOMAP PREPARED FROM BULK PROCESSED MULTI-SPECTRAL SCANNER (MSS) IMAGERY ACQUIRED BY THE NASA EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1). THE IMAGE, BAND 5, WAS ACQUIRED IN THE RED (600-700 NM) PORTION OF THE SPECTRUM ON JANUARY 25, 1973. SUBSEQUENT OVERLAYS OF VARIOUS ENVIRONMENTAL PHENOMENA WILL BE DELIVERED TO NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION INVESTIGATORS FOR USE WITH THIS BASEMAP.

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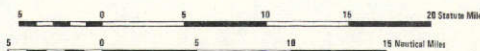


Figure 4

NEW JERSEY ERTS-1 INVESTIGATORS BASEMAP SOUTHERN SECTION



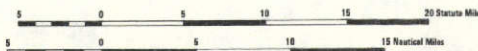
Let's protect our earth



**NEW JERSEY
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OF ENVIRONMENTAL
PROTECTION**

PHOTOMAP PREPARED FROM BULK PROCESSED MULTI-SPECTRAL SCANNER (MSS) IMAGERY ACQUIRED BY THE NASA EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1). THE IMAGE, BAND 5, WAS ACQUIRED IN THE RED (600-700 NM) PORTION OF THE SPECTRUM ON JANUARY 25, 1973. SUBSEQUENT OVERLAYS OF VARIOUS ENVIRONMENTAL PHENOMENA WILL BE DELIVERED TO NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION INVESTIGATORS FOR USE WITH THIS BASEMAP.

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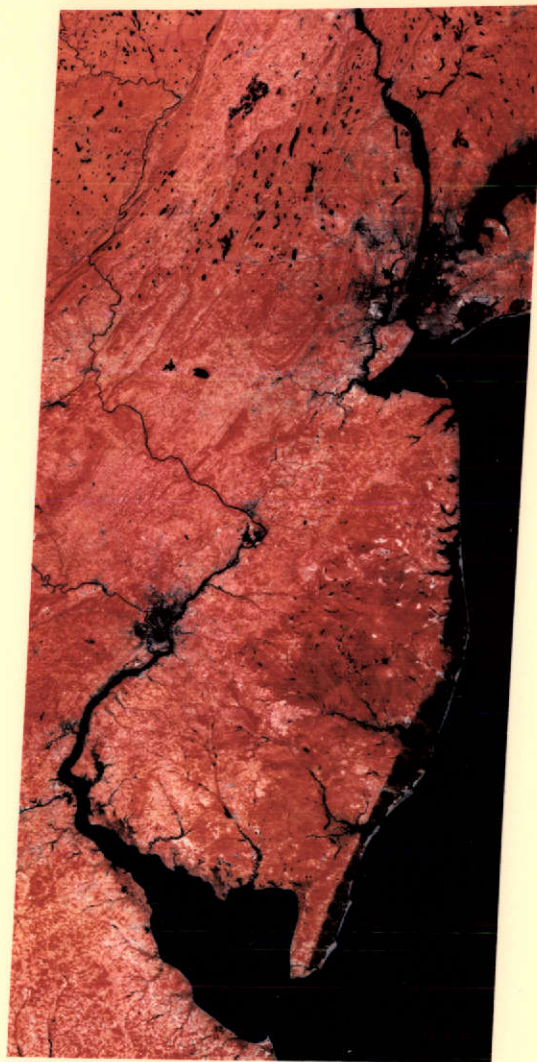


Figure 5. Color Dye Transfer Mosaic of the State of New Jersey prepared from three ERTS MSS Band 5 images taken on October 10, 1972.

effects must be understood in relation to their impact on the future of New Jersey's beaches, marine life, and public health.

Ocean dumping operations are performed 24 hours a day, 7 days per week throughout the year except under extreme weather conditions. Present ocean dumping operations in the New York Bight are regulated by the New York District Corps of Engineers which issues permits for dumping at specific ocean locations, depending on the material to be dumped. Five dumping sites are being studied using ERTS imagery:

- Acid Waste Dumping Ground
- Sewer Sludge Dumping Ground
- Cellar Dirt Dumping Ground
- Mud and One Man Stone Dumping Ground
- Wreck Dumping Ground

The dumps which have been imaged to date are primarily acid and dredge spoil. The acid is the most reflective and is dumped in a characteristic hair-pin pattern (Figure 6). The dredge spoil is heavily laden with particulates but is dumped over a much smaller area than the acid. Sewage sludge dumps contain only 1% - 3% solids and are therefore, much less reflective than the other types of dumps.

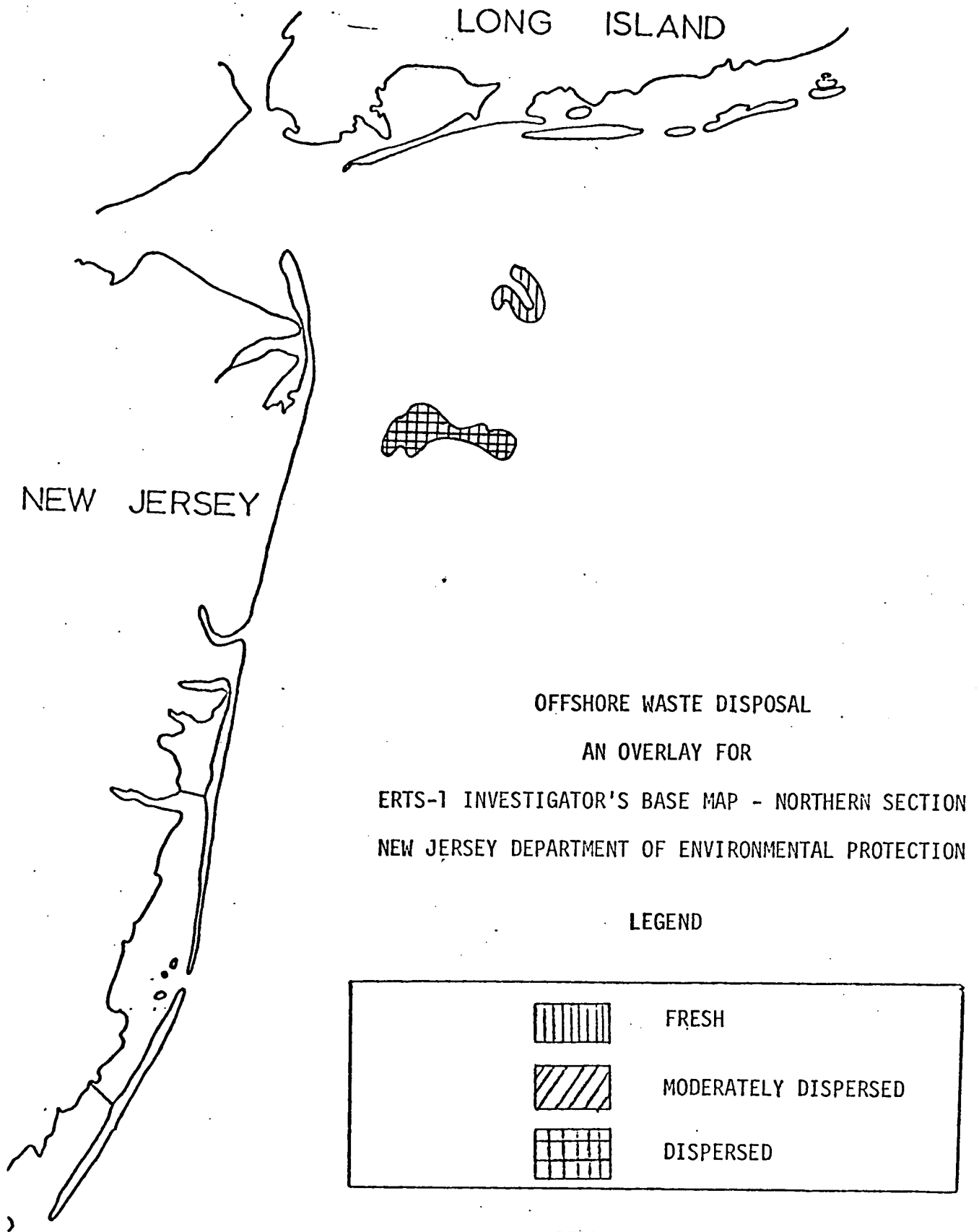
The geographical extent of dumping, the apparent direction of drift, and the dispersion characteristics, are monitored with each orbit. Dumps are classified as either fresh, moderately dispersed, or well dispersed. These data are plotted on clear acetate overlays (Figure 7) and provided to the appropriate bureau within the NJDEP. The predominant dispersion and movement of relict (imaged) dumps is west towards the New Jersey Shoreline. Dump site products are providing useful information for the



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Figure 6: NASA ERTS-1 MSS Band 5 illustrating the extent of acid waste disposal. Print is 1:500,000 scale; one inch equals approximately 8 miles.

Figure 7



SEPTEMBER 22, 1972

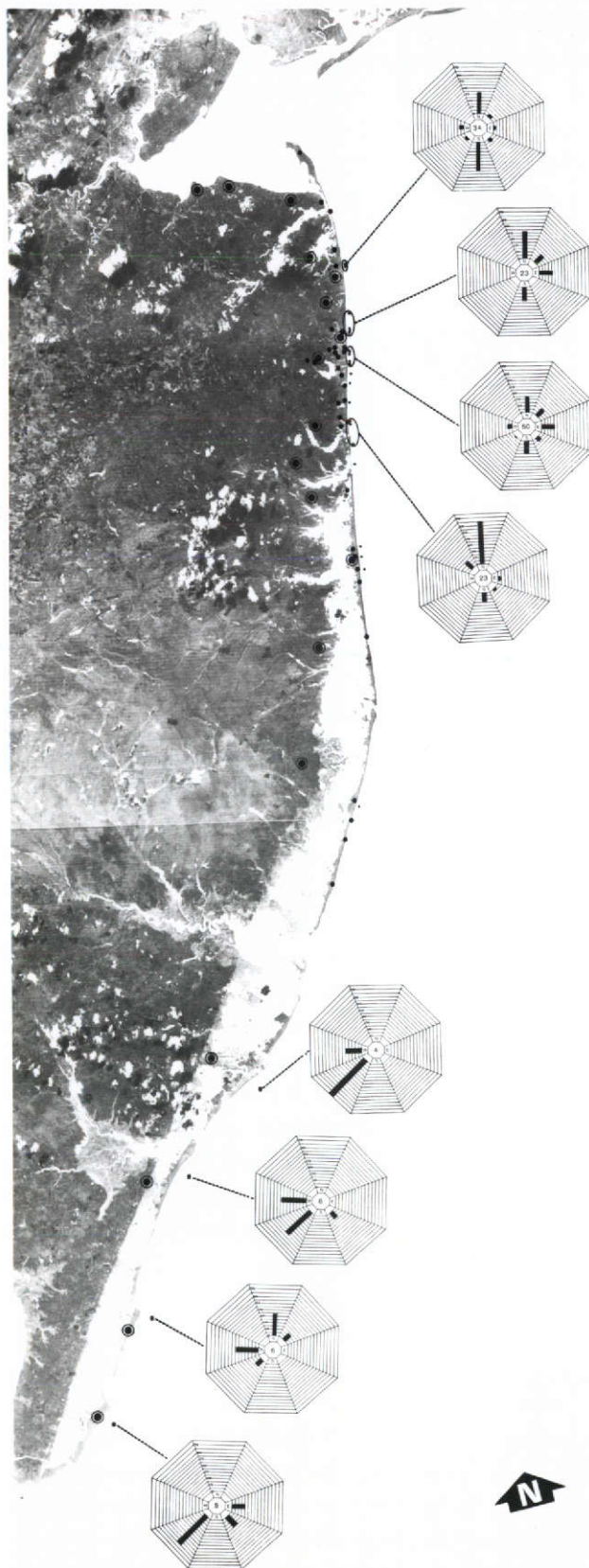
establishment of water quality sampling criteria applicable to the disposal of wastes, for assessing trends and changes in the dispersion and movement of waste materials and for identifying pollution problem areas that require investigation by NJDEP or EPA personnel.

5.2 Ocean Outfall Placement

The objective of this portion of the investigation is to develop nearshore circulation information that could be integrated into NJDEP's plan for regionalized ocean outfalls. New Jersey has planned a regionalized sewage disposal network which includes sixteen ocean outfalls. Some of these outfalls have already been built, but others are still in the design stage and could benefit from additional information on coastal current systems. To date, outfall design for coastal New Jersey has not relied heavily upon marine current information; the dilution ratio of effluent from the bottom to the surface has been the predominant factor in designing ocean outfalls.

Analysis of ERTS imagery and complementary aircraft photography have led to several products on circulation dynamics that could provide additional information to the Division of Water Resources for the environmentally sound design of ocean outfalls. Rosette diagrams (Figure 8) are used to present the percent of time that surface currents may be expected to flow in the directions indicated within a one mile area just outside the littoral zone. These data sets were compiled from data from seventeen (17) orbits of ERTS-1, nineteen (19) years of supplementary

Figure 8



OUTFALL PLANNING MAP

NEARSHORE CURRENTS

NEW JERSEY COASTAL AREA

Let's protect our earth



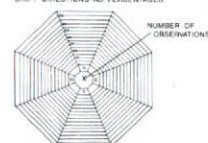
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

THESE DATA SHOW THE PERCENT OF THE SURFACE CURRENTS HAVE BEEN OBSERVED TO FLOW IN THE DIRECTIONS INDICATED WITHIN AN AREA JUST OUTSIDE THE LITTORAL ZONE EXTENDING TO ONE (1) MILE OFFSHORE. THESE DATA SETS WERE COMPILED FROM A COMBINATION OF INPUTS FROM SEVENTEEN (17) ORBITS OF THE EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1), NINETEEN (19) YEARS OF SUPPLEMENTARY AIRCRAFT PHOTOGRAPHY INCLUDING NASA SUPPORT MISSIONS, AND FROM INDEPENDENT STUDIES. THE AREAS CHOSEN FOR ANALYSIS ARE BASED ON THE PROPOSED LOCATIONS FOR NEW JERSEY'S REGIONALIZED OCEAN OUTFALLS AND THE AVAILABILITY OF USEFUL DATA. INFORMATION CONTAINED HEREIN INDICATES A PREDOMINANT NORTH-SOUTH FLOW ALONG THE NEW JERSEY COAST EXCEPT AT POINTS NEAR TIDAL INLETS WHERE A ROTARY FLOW CAN BE EXPECTED. THE PHOTOMAP ON WHICH THIS INFORMATION IS PLOTTED WAS PREPARED FROM BULK PROCESSED MULTISPECTRAL SCANNER (MSS) IMAGERY ACQUIRED BY THE NASA EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1). THE IMAGE, A NEGATIVE OF BAND 7, WAS ACQUIRED IN THE NEAR INFRARED PORTION (800 - 1100 NANOMETERS) OF THE SPECTRUM.

LEGEND

- PROPOSED REGIONAL TREATMENT FACILITY
- SEWAGE PLANTS PRESENTLY DISCHARGING INTO ATLANTIC OCEAN
- OBSERVED OUTFALL LOCATIONS
- DYE SOURCE LOCATIONS

DRIFT DIRECTIONS AS PERCENTAGES



SCALE



EARTH SATELLITE CORPORATION
1747 Pennsylvania Avenue
Washington, D.C. 20006



aircraft photography, and historical ground records. The areas chosen for analysis are largely based on the proposed locations for New Jersey's Regionalized Ocean Outfalls. Data analysis indicates that a predominant north-south flow exists along the New Jersey coast, except at points near tidal inlets where a rotary flow can be expected. NJDEP and EarthSat are working closely with the local sewerage authorities and the design engineers to develop the necessary marine current data needed to plan sewage disposal systems that are in balance with the surrounding environment.

The monitoring of existing ocean outfalls (Figure 9) is a continuing task as part of this investigation. New Jersey has numerous ocean outfalls of various capacities and ERTS and aircraft image analysis has shown some patterns of surface plume movement at selected outfalls, that cover all possible points of the compass. The most predominant factor in the movement of surface outfall plumes has been the wind, and since the prevailing winds that occur in coastal areas are onshore, the need to understand the movement of surface waters becomes very important. Figure 10 represents the maximum displacements of surface plumes for four different compass directions. Maximum observed surface plume length has been measured at 4500' whereas many of New Jersey's outfalls are only 1000' offshore. When the prevailing surface currents are onshore, there is a definite large scale inundation of the beach at and around these outfall locations by the sewage outfall effluent.

A preliminary statistical analysis of surface currents based on historical wind data for coastal New Jersey, and the threshold wind velocities needed to produce a significant surface current, shows that more

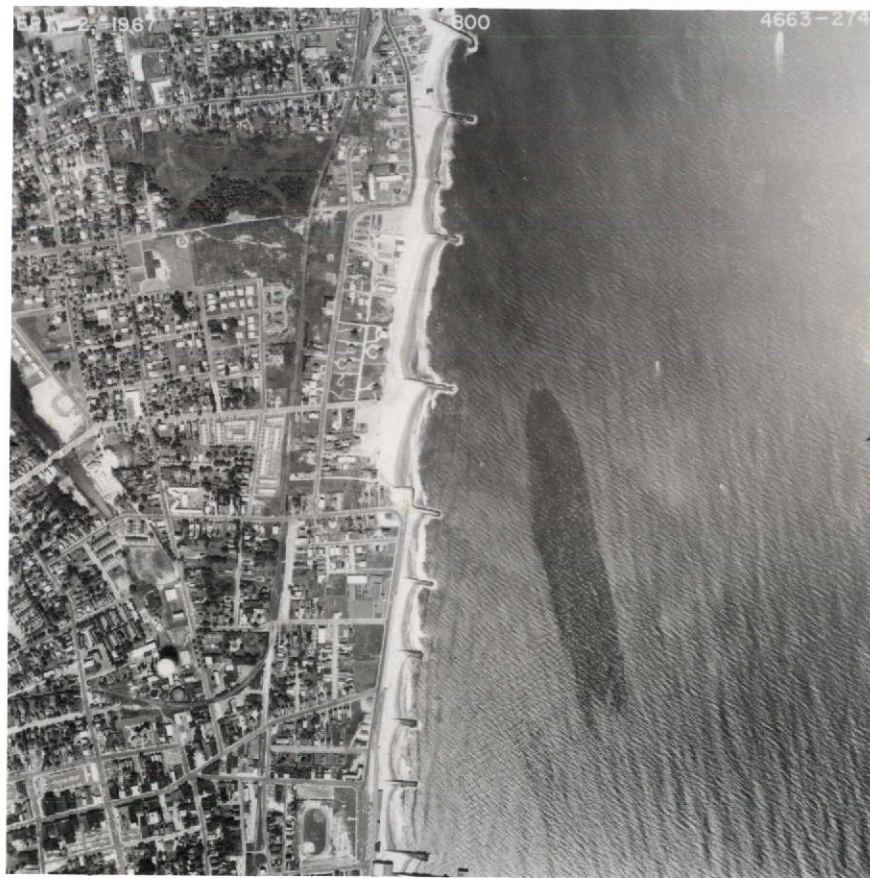
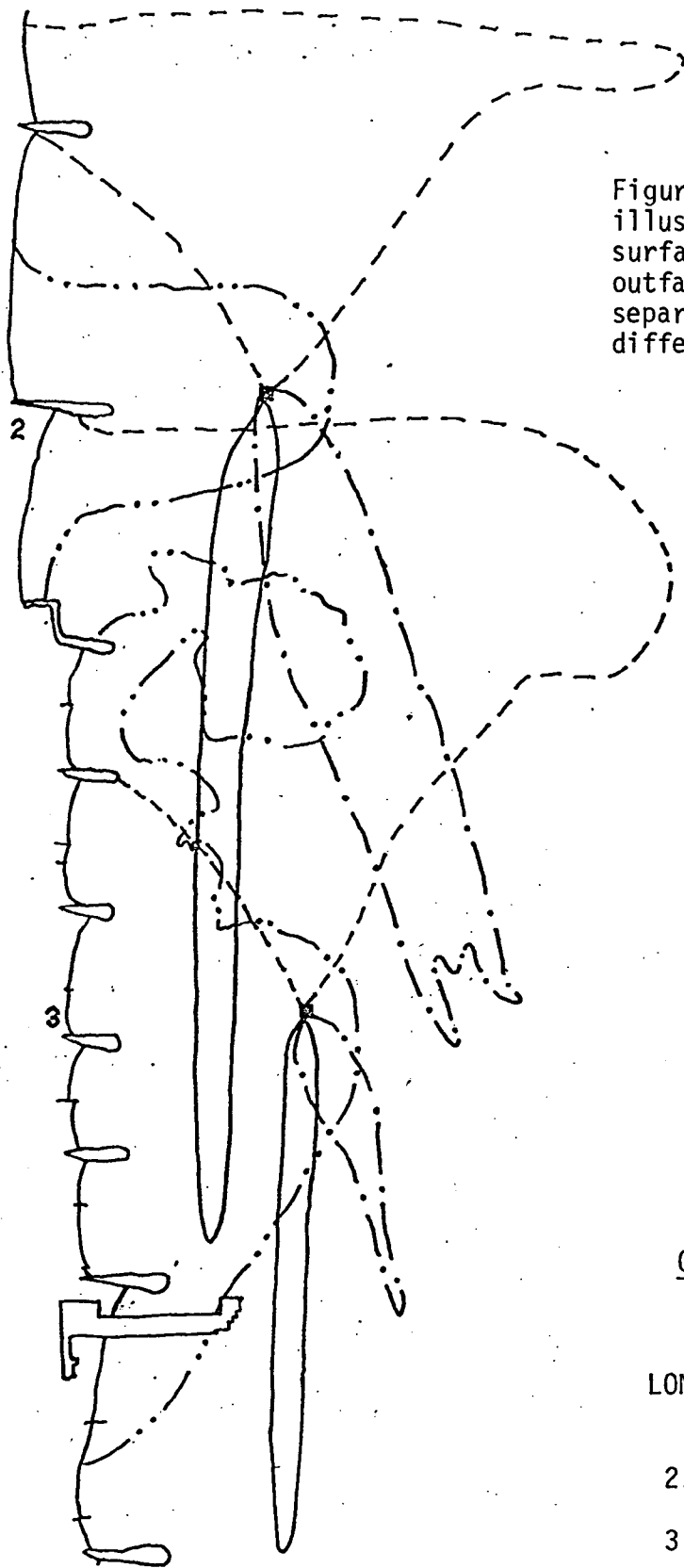


Figure 9. Aerial photograph of a typical ocean outfall plume as seen on the ocean's surface. The elongated dispersal pattern is characteristic of diffusion theory.

Figure 10. Line drawing illustrating the maximum surface movements of sewage outfall effluent on four separate days having four different wind conditions.



OCEAN OUTFALLS

1" = 800'

LONG BRANCH, NEW JERSEY

2. JOLINE AVENUE

3. BROADWAY AVENUE

than 60% of the time the surface current is onshore.

5.3 Coastal Zone (Land) Resources

5.3.1 Ecozones Discrimination

The small scale synoptic view provided by ERTS has been used in this portion of the investigation for the recognition and delineation of regionally similar land areas, called ecozones. Ecozones are defined, in this instance, as regional areas of at least 200 square miles characterized by homogenous interrelationships of soils, landforms, vegetation, geology, and land use.

An Ecozone Map and a descriptive brochure (Appendix C) have been prepared from ERTS analysis and will be a direct input to a regional environmental design planning program presently underway in NJDEP. Ecologically unique areas can be recognized and thus suitably managed at the planning stage.

A photointerpretive analysis of MSS Band 5 led to the delineation of fifteen ecozones. A line was drawn around each area which, according to its tone, texture, pattern and extent, appeared as a distinct land resource unit. For example, the Coastal Zone was delineated by the dark tones of the back-bay areas, the somewhat lighter tones of the wetlands, and the bright tones of the barrier beaches. The Pine Barrens imaged as a dark toned, velvety textured, extensive land area broken only by a few light toned roads and dark toned dendritic patterns of river drainage networks. The Agricultural Belt imaged a very light mottled tone of highly reflective vegetative areas.

Urban and industrial areas around Trenton, Camden, and Newark, were distinguished by their subtly mottled, light grey tones.

Having thus delineated the fifteen areas on the ERTS imagery, a descriptive classification scheme was formulated giving attention to New Jersey's geography and land use; Table 1 illustrates that classification scheme. The Regional Ecological Map (Figure 11) is a reproduction of the ecozones overlay. The final product of this portion of the ERTS investigation will be a photo-reproduction of the three-frame ERTS mosaic of New Jersey, including the ecozone overlay. This product will show the tones and textures of New Jersey's landscape mentioned above, which were used in the delineation of the State's ecozones.

The Ecozone Map prepared exclusively from ERTS imagery is an important land use and coastal zone management tool to NJDEP. The State's Environmental Design will place great emphasis on the practical and environmentally sound use of coastal land resources. Ecozone development is a first step in developing planning units which have greater meaning than simple geographic subdivisions such as county lines.

5.3.2 Coastal Ecozone Subunit Classification

Within the Coastal Ecozone, significantly different land resource areas and land-use occur. These areas were delineated (Figure 12) from analysis of ERTS imagery as ecozone subunits. A description of the six subunits accompanied by background information follows:

TABLE 1

- I. COASTAL ZONE: area of coastal land and water including the wetlands, barrier islands, bays and inlets which are directly affected by coastal processes
- II. PINE BARRENS: level area of contiguous forest cover with low intensity land use and a marked absence of agriculture
- III. LAKEWOOD: forest area with extensive residential and commercial development; mixed land use
- IV. VINELAND: area of mixed agriculture and forest; remnant forests line dendritic drainageways
- V. AGRICULTURAL BELT: area of extensive farming with small forest woodlots and some residential and urban development; includes most of the best farmland in New Jersey
- VI. URBAN AND INDUSTRIAL ZONE: industrialized, densely urbanized areas of intensive land use
- VII. PIEDMONT PLAIN: area of mixed, moderate-yield cropland and urban land use with scattered, forested traprock ridges
- VIII. HUNTERDON PLATEAU: area of curvilinear forested ridges and cleared valleys with relatively low yield cropland
- IX. UPPER DELAWARE RIDGE AND TERRACE: area of rolling terrain in which forest cover and agricultural use predominate
- X. KITTATINNY MOUNTAIN: a steep series of heavily forested ridges of low intensity land use
- XI. KITTATINNY VALLEY: rolling topography consisting of forested ridges and valleys with small lakes dotting the landscape; farming is practiced on cleared valley floors
- XII. HIGHLANDS: rugged, partially forested, mountainous area containing numerous lakes; valleys have been cleared for agricultural use
- XIII. WASHINGTON: level valley enclosed by Highlands Ecozone; rural land use-intensive agriculture predominates
- XIV. PASSAIC BASIN/WACHUNG MOUNTAINS: urban land use and forest cover predominate in this relatively level river basin ringed by a lightly developed area of forested, traprock ridges.
- XV. RIDGEWOOD: urban land use and forest cover predominate in this area; topography is similar to the Piedmont Plain Ecozone

Figure 11

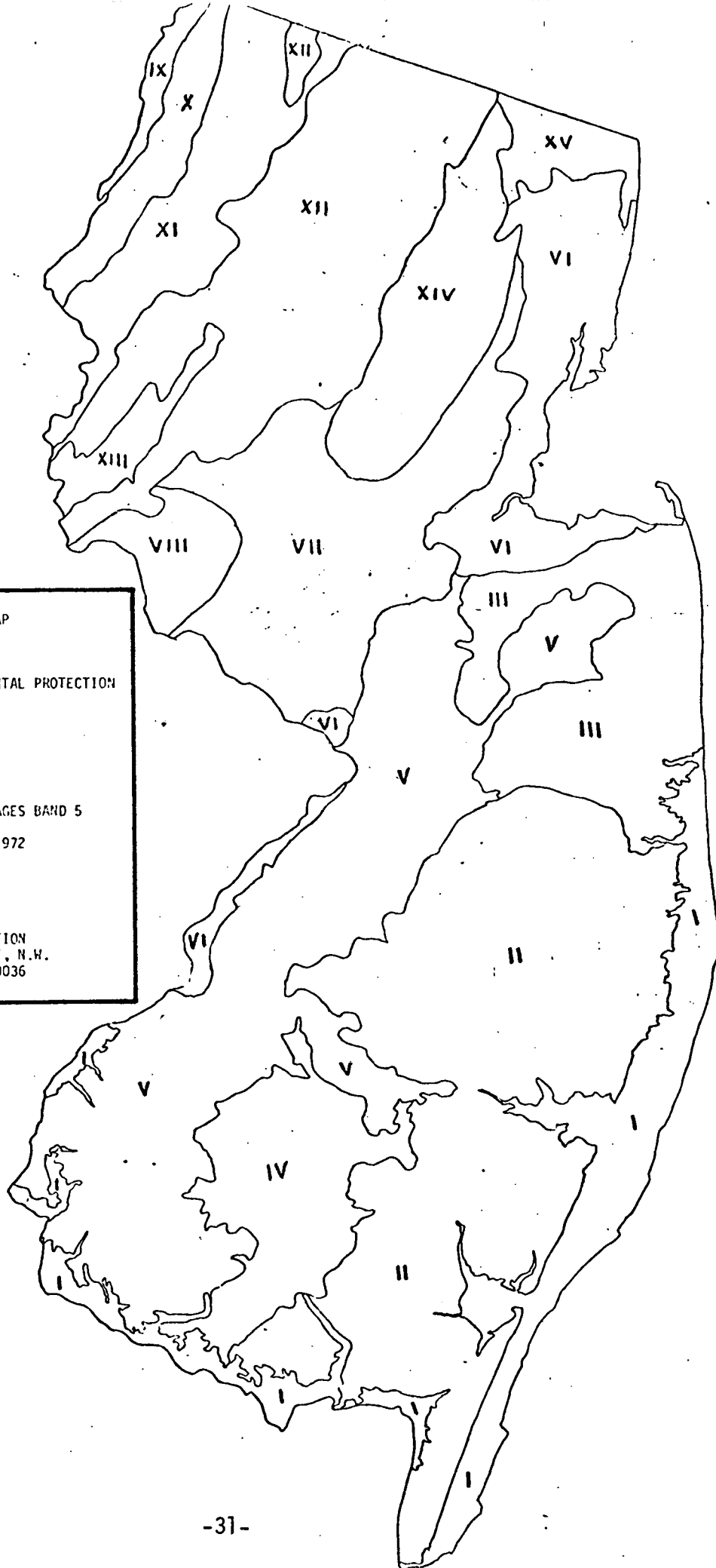
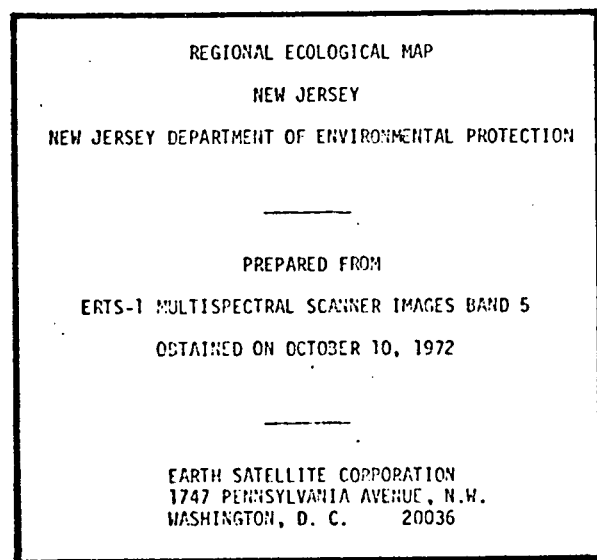


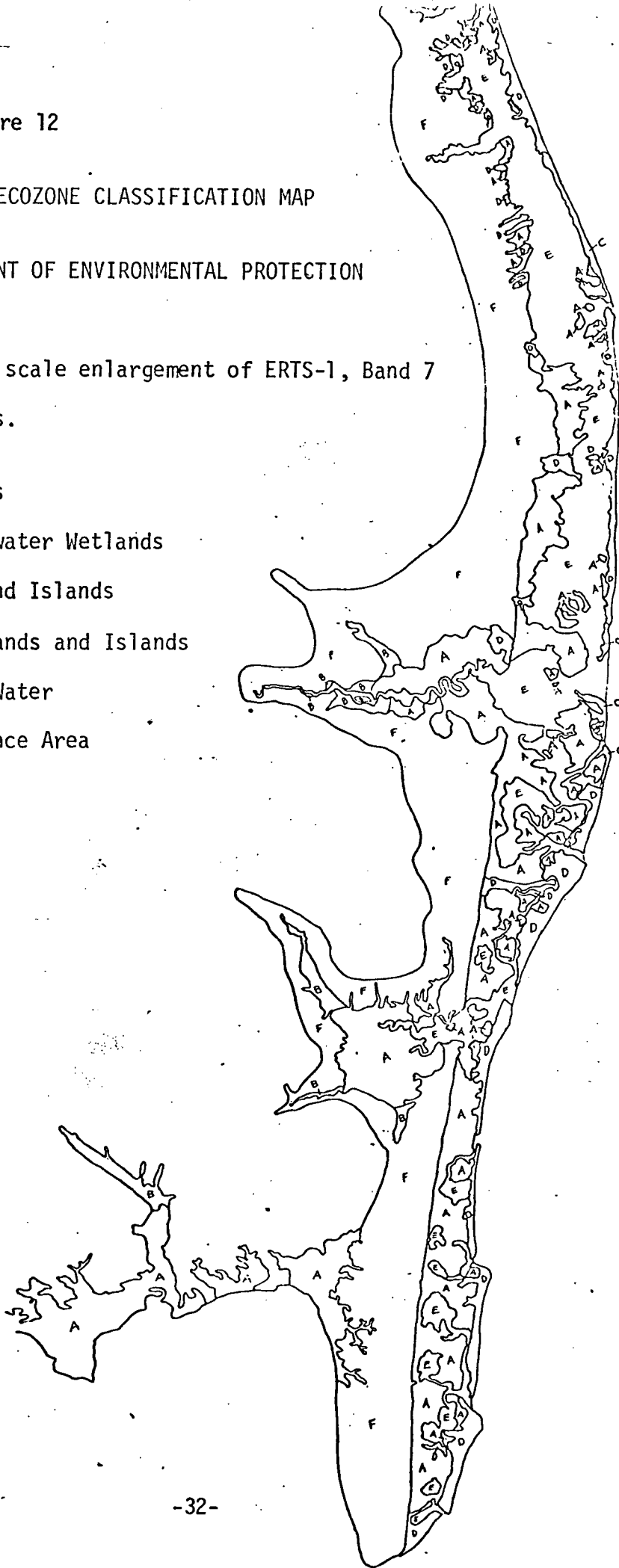
Figure 12

COASTAL ZONE ECOZONE CLASSIFICATION MAP

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Prepared from 1:250,000 scale enlargement of ERTS-1, Band 7
October 9, 1972 overpass.

- A. Saline Wetlands
- B. Brackish/Freshwater Wetlands
- C. Barrier Bars and Islands
- D. Developed Wetlands and Islands
- E. Intra-Coastal Water
- F. Coastal Influence Area



- A. Saline Wetlands: Those wetlands marsh areas which are predominantly composed of saline vegetation are included within this classification. They characteristically occur in the lee of barrier bars and islands, and on the coastal edge of the mainland.
- B. Brackish/Freshwater Wetlands: Areas of predominantly brackish-freshwater marsh vegetation which commonly occur in the estuaries of coastal rivers and streams and along the northern edge of the Delaware Bay.
- C. Barrier Bars and Islands: Sandy areas which are characterized by the development of beaches, back-shore dunes, offshore bars and littoral hooks or spits. These areas contain a unique form of xerophytic vegetation which serves to stabilize dunal formations.
- D. Developed Wetlands and Islands: Areas of intensive development (e.g., Atlantic City) may be detected on the ERTS imagery and are recognized as unique subunits. Areas of moderate intensity development or less were not identified.
- E. Intra-Coastal Water: Area protected by offshore barrier islands in which confluence of freshwater and saline ocean water occurs.

F. Coastal Influence Area:^{1/} Upland area, the use of which influences the coastal resources. Resorts, residential communities, and service industries chiefly comprise this area.

A 1:250,000 scale enlargement of ERTS MSS Band 7 from the October 9, 1972 overpass was analyzed with the aid of a color composite of Bands 4, 5, and 7 from the same date. Areas of similar tone and texture were delineated on an overlay at 1:250,000 scale utilizing a knowledge of the land-use and ecology of the New Jersey coast and wetlands. The land/water areas thus delineated were described in words to form the description classification scheme above. The final product, a photo-reproduction of the ERTS mosaic overlaid by the Subunit Classification, will be used by the NJDEP environmental design team in planning efforts for the Coastal Zone. Figure 12 is a reproduction of the subunit Overlay and its classification categories.

An ERTS photomap (Figure 13) of New Jersey's Coastal Area was prepared for NJDEP's use and was instrumental in the passage of new legislation, "The Coastal Area Facility Review Act."

^{1/} Monitoring of this area using ERTS promises to be most important in light of new legislation; the Coastal Area Facility Review Act. As the State's Wetlands Act of 1970 limits wetlands development, pressures may be transferred to upland sections.

Figure 13

NEW JERSEY COASTAL AREA

Let's protect our earth

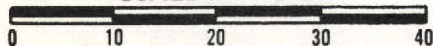


NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

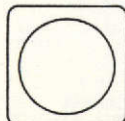
The Legislature finds and declares that New Jersey's bays, harbors, sounds, wetlands, inlets, the tidal portions of fresh, saline, or partially saline streams and tributaries and their adjoining upland fastland drainage area nets, channels, estuaries, barrier beaches, near shore waters, and intertidal areas together constitute an exceptional, unique, irreplaceable, and delicately balanced physical, chemical, and biologically acting and interacting natural environmental resource called the coastal area, that certain portions of the coastal area are now suffering serious adverse environmental effects resulting from existing facility activity impacts that would preclude or tend to preclude those multiple uses which support diversity and are in the best long-term social, economic, aesthetic, and recreational interests of all people of the State; and that, therefore, it is in the interest of the people of the State that all of the coastal area should be dedicated to those kinds of land mix uses which promote the public health, safety, and welfare, protect public and private property, and are reasonably consistent and compatible with the natural laws governing the physical, chemical, and biological environment of the coastal area.



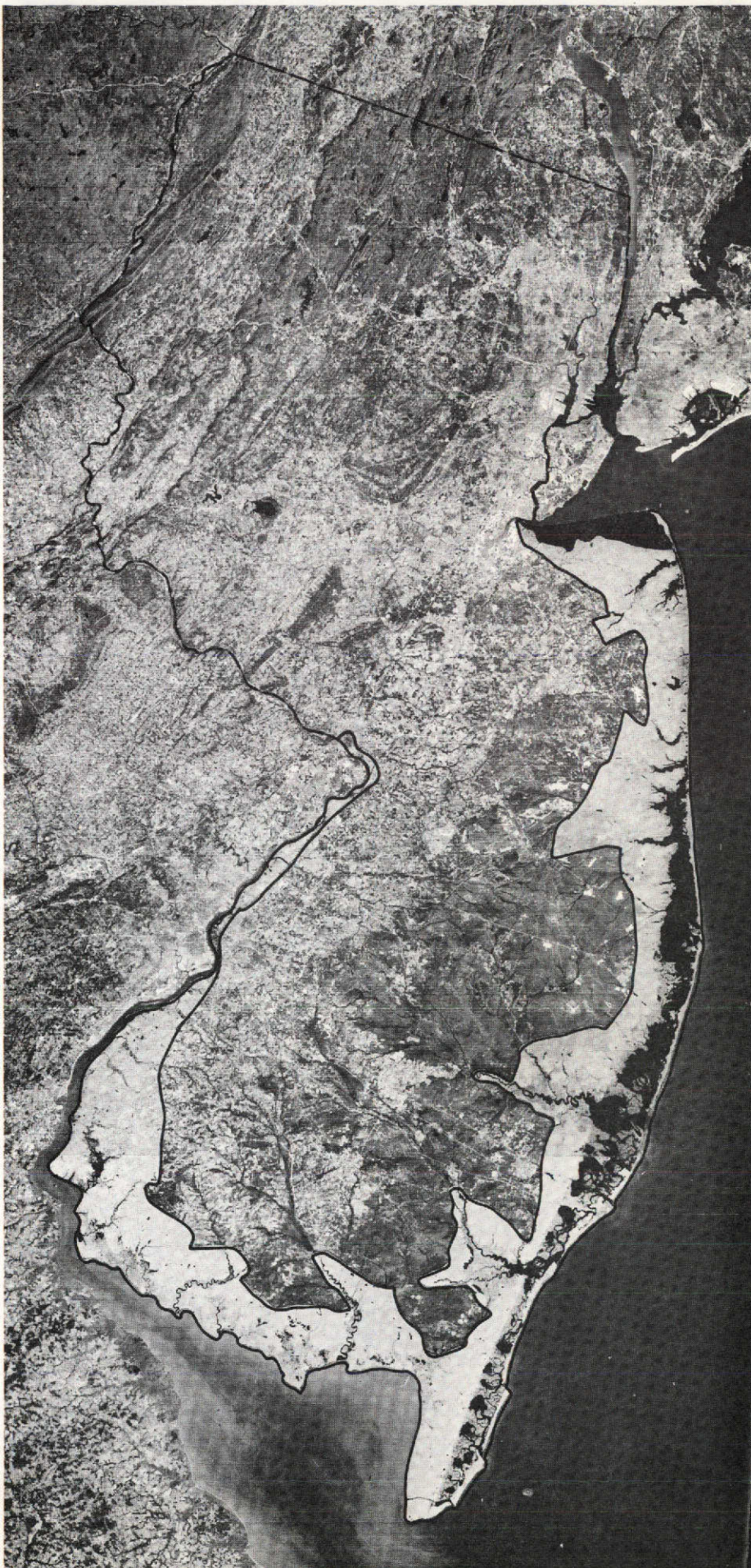
SCALE IN MILES



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ENVIRONMENTAL
APPLICATIONS DIV.
WASHINGTON, D.C.



5.3.3 Coastal Zone Surveillance Program

Sequential ERTS imagery is being utilized to periodically identify significant areas of disturbance within the coastal zone. The initial analysis effort has served as a basis for structuring a coastal zone surveillance program to periodically supply environmental information to the NJDEP.

Comparisons of coastal areas have been made between recently acquired ERTS images and frames obtained on earlier dates. Systematic comparisons of the same areas are utilized to identify where changes have occurred.

Land clearing as well as dredging and filling operations result in a highly altered land surface. This surface will frequently exhibit unique ERTS image characteristics, enabling the differentiation of natural cover (e.g., marsh land and forest land) from altered areas (e.g., land under development). Because of the relatively low resolution of the ERTS system, altered areas must usually cover at least two or three acres before they can be consistently resolved. Those land use changes which are detected represent major land or waterscape alterations, the location of which need to be known by the NJDEP.

The results of ERTS analysis for coastal surveillance are presented in the following product formats and in Appendix D:

- ERTS Photo Base Map: Areas of suspected alteration are annotated on clear acetate overlays for the 1:250,000 NJDEP basemaps. This map serves to indicate the general position and relative concentration of sus-

pected areas on a regional basis. It can be used to broadly plan field inspection activities. A comparison between observed alterations in the coastal zone and existing permits can be rapidly accomplished.

- Photoquad Sheets: The detailed location of each suspected alteration is annotated on New Jersey photoquad sheets (dated April, 1972) which correspond to standard 1:24,000 USGS topographic map sheets (Figure 14). These photoquad sheets will serve as a working guide to direct wetlands inspectors or other personnel to the particular sites of suspected alterations.

The sample wetlands surveillance report (Figure 15) contains a relatively small number of detected land surface alterations. All changes detected from ERTS are summarized in Table 2. It was recognized at the outset that the likelihood of detecting changes (mainly dredge-and-fill operations) within wetlands areas would be minimized due to the moratorium on development in effect since 1970. A dramatic reduction in the frequency of dredge-and-fill operations has been confirmed through ERTS analysis.

The seasonal nature of large scale land development and construction is an important factor affecting the necessary frequency of observations. Such activities are frequently begun during the spring and summer months, and occur least commonly during the winter months. Since the interval of ERTS analysis for these investigations was October through early April, it is reasonable to expect that little clearing, filling or new construction would have been initiated. Further comparisons of ERTS imagery acquired during

TABLE 2
SUMMARY OF ERTS-1 IMAGERY DATES
FOR WHICH COASTAL ZONE SURVEILLANCE CHANGES WERE OBSERVED ^{1/}

SITE #	PHOTOQUAD	1972	1973			13 May
		10 October	25 January	13 February	7 April	
1	Point Pleasant		NC	NC	X	NC
2	Toms River		X	(Area Widened)	NC	(Area Expanded To South)
3	Toms River/ Keswick Grove		X	NC	NC	NC
4	Forked River		X	NC	NC	NC
5a	Ship Bottom/ Forked River		NC	NC	NC	X
5b	Ship Bottom/ Forked River		X	NC	NC	NC
5c	Ship Bottom/ Forked River		NC	NC	NC	X
6	Oceanville		X	NC	NC	(Forest Cleared From Interior Of Area)
7a	Marmora		X	NC	NC	NC
7b	Marmora		X	NC	NC	NC
7c	Marmora		X	(Slight Enlarge- ment)	NC	(Possible Slight En- largement)
7d	Marmora		NC	X	NC	NC
8	Marmora		NC	(Ice Cover)	X	NC

^{1/} X= First ERTS-1 imagery date for which significant change detected.

NC= No change since previous date



SHIP BOTTOM

-DATE OF PHOTOGRAPHY: MARCH-APRIL, 1972 -

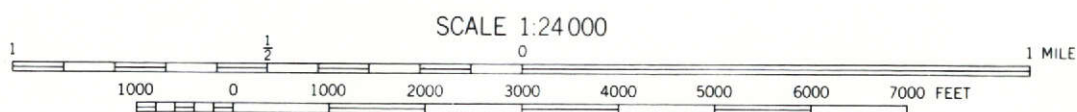


Figure 14: Area delineated on this 1:24,000 scale photoquad sheet represents the development-change detected on the ERTS-1 imagery between 1-25-73 and 5-13-73.

This report sheet is intended as a convenient means of documenting the utility of ERTS-derived wetlands surveillance data and for improving the format for its presentation.

COASTAL ZONE SURVEILLANCE REPORT SHEET

EARTH SATELLITE USE

LOCATION/DESCRIPTION

Photoquad name (USGS 7 1/2' map sheet): Ship Bottom/Forked River

General Location: (SITE #5) Southwest of Barnegat, between Route 9 and Bay Avenue

Calendar Date When Change Detected: 25 January 1973 (SITE 5B)
13 May 1973 (SITES 5A, 5C)

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION USE

FIELD INSPECTION REPORT

Date Visited:

Total Time Required for Travel and Evaluation:

(Starting point:)

Problems Encountered Reaching Area (describe):

Nature of Disturbance:

Person, Agent, or Company Responsible:

(Permit: ☐ yes ☐ no)
Source:

Area Affected, Acres (estimate):

Obvious Environmental Impacts of Disturbance:

Other Comments, Observations:

Figure 15

the spring and fall will reveal whether the pace of development has, in fact, accelerated.

During the interval of ERTS analysis (October 10, 1972 to April 7, 1973), a small number of changes were detected. Several of these changes were observed on upland areas adjacent to wetlands within the "coastal area." ^{1/}

It appears that the moratorium on wetlands development has shifted the focus of development from the wetland environment to the relatively undeveloped upland forested zone adjacent to it. Monitoring of land use change throughout the "coastal area" can provide data necessary for assessment of relative developmental pressures. Equally significant, this technique may provide information useful for implementing the "Coastal Zone Act."

5.3.4 Coastal Wetlands Discrimination

The ability to conduct general wetlands delineation was assessed using a 1:1,000,000 scale ERTS color composite and an enlarged 1:60,000 mosaic of Band 5 (1079-15133, October 10, 1972). Visual inspection of this and other ERTS data (mostly outside the vegetation growing season) indicate that large wetlands areas are clearly imaged. Close examination indicated that species composition of the wetlands is difficult on the color composite due

^{1/} Defined by the State in the Coastal Protection Act as constituting a unique, irreplaceable resource worthy of protection and balanced development.

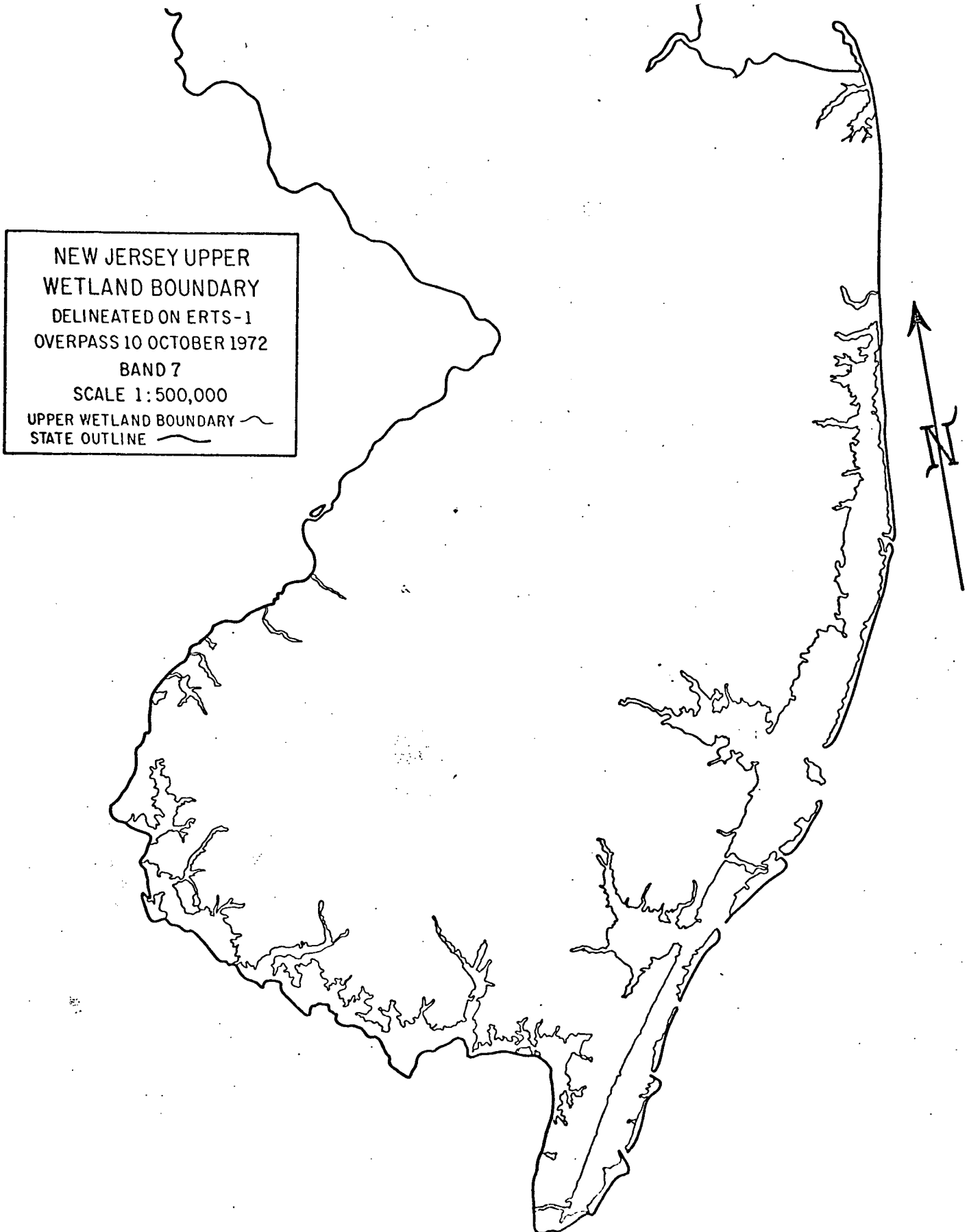
to small scale and in the enlargement due to poor tonal contrast on Band 5.

False color enhancement on the I²S Addcol improved species discrimination somewhat. In the Beach Haven West area, some large stands of Spartina alterniflora can be distinguished from stands of Spartina patens.

The wetland perimeter can be located successfully, and changes (reductions) in wetland area resulting from development can be monitored if the areas are of sufficient size.

ERTS-1 color composites (1:1,000,000) and a mosaic of MSS Band 7 (1:500,000) were used to delineate an upper wetland boundary (Figure 16) for coastal New Jersey. The pink to reddish tonal signatures of the wetland vegetation, the position of the vegetation between barrier beaches and the mainland, and along tidal streams, all aided in the identification and separation of wetland from upland areas. The tonal and textural signatures of wetland vegetation were considerably different from those of upland plant species and the boundary was drawn along a distant tonal and textural break. Along the Delaware River, tonal signatures indicative of wetland species could be identified along stream channels, but these signatures were more difficult to identify than those seen along the coast.

Figure 16



5.4 Estuarine Flushing Dynamics

New Jersey is subjected to statewide pressures of a growing population and rapid industrialization while attempting to maintain its primary resource: recreation. These pressures are most sharply felt in southern New Jersey; since this area's primary resource is its beaches. Local municipalities over the years have dumped their wastes into the back-bay estuarine areas rather than in ocean outfalls, as is the practice in the North. The capacity of these waters to assimilate these wastes has been reached in many areas. In order to protect its environment, NJDEP is using ERTS data to generate information on its estuarine environments which have a finite capacity to assimilate and cleanse themselves of wastes. There is a need to know the rates at which an estuary can flush itself of pollutants, the number of tidal cycles it takes to remove particular pollutants, the assimilative capacity of estuaries, and the effects of an estuarine discharge on nearshore marine environments. Such information is essential to the environmentally sound development of New Jersey's coastal zone.

In response to this need, EarthSat is using ERTS and complementary aircraft data to quantify the amount of water that is tidally flushed through an inlet with each tidal cycle. Analysis is underway incorporating the back-basin geometry, tidal prism, turbidity, and modeled dispersion coefficients to compare the actual volumes discharged to the normalized reflectance values in the nearshore and estuarine waters. These estimates of flushing capacity will be used by the Division of Water Resources to

ensure environmentally sound growth, if in fact, growth is possible.

At the present time, approximately 26 MGD's of domestic and industrial effluents (85% of which is only receiving primary treatment) are being emptied into the waters behind the barrier islands fronting the Atlantic City, Margate, and Ventnor areas. Comparisons are being made between the surface size of estuarine discharge plumes from one orbit to another. By comparing these data to tidal stage, an estimate of water volume is being made.

5.5 Shore Protection

Manual and optical analysis ^{1/} of ERTS imagery to date, strongly suggests that achievement of the experiment objectives directed towards shore protection planning, appear not to be within the system capabilities of ERTS.

The temporal scale for monitoring the dynamic systems causing shoreline changes and the spatial resolutions required to accurately measure a majority of these changes are not generally met by ERTS-1. The ERTS satellite is capable of the repetitive coverage needed to monitor long-term shoreline changes, but better resolution is required for acquiring shore protection data. However, ERTS-1 mosaics have been used as a base-map to plot information derived from historical records and measurements from sequential ERTS aircraft support data. The ERTS-1 mosaics are useful to NJDEP in gaining an overview of the coastal environments of

^{1/} : Computer enhancement techniques may serve to accentuate subtle coastal current patterns and/or shoreline changes. This was not budgeted and add-on funding will be requested.

New Jersey and are illustrative of how various environmental factors (storms, winds, currents, and waves) modify the coastline.

A shore protection information product (Figure 17) has been prepared which illustrates a comparison of beach ownership versus erosional characteristics versus dollars requested for shore protection in fiscal 1972. This product is a management tool for NJDEP personnel who are responsible for shore protective structures funds allocation. Those areas are represented in which the most dollars have been spent as compared with those areas in which few dollars have been spent.

6.0 PROGRAM FOR NEXT REPORTING PERIOD

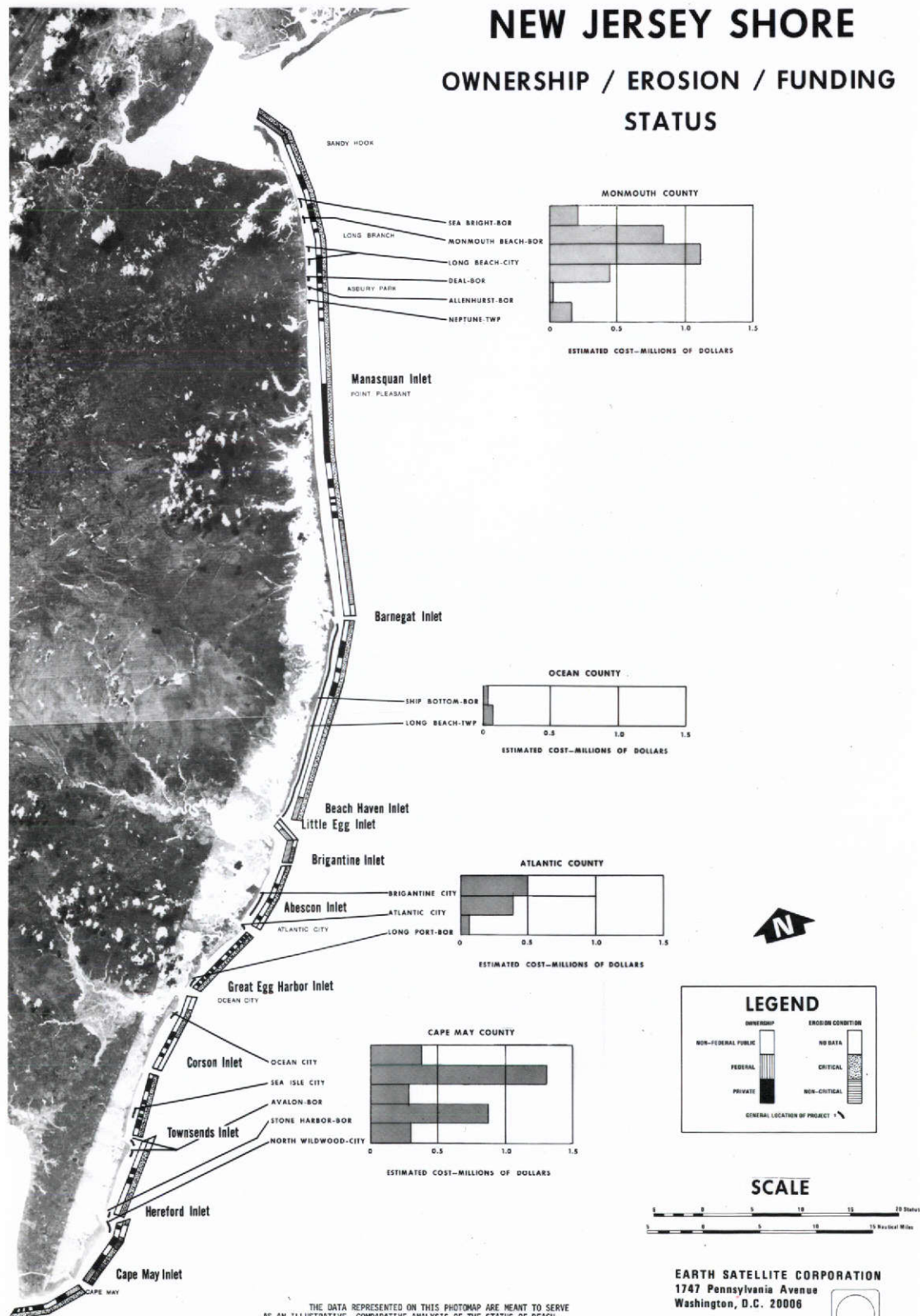
6.1 Task Summary

- Continue analysis of all incoming ERTS and aircraft imagery for NJDEP as received by EarthSat.
- Routinely monitor and prepare New York Bight offshore waste disposal overlays illustrating dispersion patterns and directions of movement.
- Continue to attempt to discriminate (by spectral comparisons) and categorize for state offices the different waste materials dumped offshore.
- Coordinate the dye-flushing of all State ocean outfalls with an ERTS/aircraft overpass in an attempt to delineate current variations along the coast, synoptically.

Figure 17

1972 NEW JERSEY SHORE

OWNERSHIP / EROSION / FUNDING STATUS



THE DATA REPRESENTED ON THIS PHOTOMAP ARE MEANT TO SERVE AS AN ILLUSTRATIVE, COMPARATIVE ANALYSIS OF THE STATUS OF BEACH OWNERSHIP VS. EROSIONAL CHARACTERISTICS VS. SHORE PROTECTION FUNDING REQUESTS FOR FY 1972. THE PHOTOMAP WAS PREPARED FROM BULK PROCESSED MULTISPECTRAL SCANNER (MSS) IMAGERY ACQUIRED BY THE EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1) ON OCTOBER 9, 1972.

- Develop a recognition technique from ERTS to determine percent cover of sea lettuce and eel grass in New Jersey's back-bays as an aid in establishing hunting bag limits for Brant in the Atlantic Flyway. A preliminary analysis of spectral differences shows promise. These data will provide game management personnel information upon which to implement bag limits and hunting season length for the Atlantic Brant.
- Attempt to discriminate a red-tide bloom from surrounding waters by MSS spectral comparisons and ground truth measurements. NJDEP will have personnel on standby for each ERTS overpass to provide ground measurements necessary for corroboration.
- Investigate the possibility of making a small scale map of New Jersey coastal wetlands from ERTS or high altitude aircraft data, that delineates all areas of Spartina patens, a species associated with the breeding habitat of the salt marsh mosquito, to be used by NJDEP in management and direction of mosquito control measures.
- Continue routine reporting to NJDEP, any changes in areas noted on successive ERTS overpasses within the legally described Coastal Area and more specifically in the wetlands, to further evaluate ERTS as a monitor for change detection and ultimately as an implement to enforcement of the Coastal Zone regulations.

- Develop destructive wave impingement maps for the New Jersey shore illustrating damaging wave approaches statistically analyzed from historical records.
- Produce an overlay map of predominant offshore circulation for the 1:500,000 New Jersey ERTS-1 basemap.
- Prepare sections of Final Report as analysis proceeds.
- Establish letter contracts with other coastal states detailing NJDEP program objectives, principal products, and results to date.

7.0 CONCLUSIONS

A principal objective of the ERTS program - user involvement and solution to natural resources problems - is being met in New Jersey. Analysis of ERTS-1 imagery and support aircraft photography and the development of information products derived from these data, are providing coastal management information to the NJDEP for the regulation and protection of the State's coastal resources.

ERTS-1 imagery is useful for monitoring offshore waste disposal, for detecting changes (primarily development) in the coastal zone, in monitoring large scale circulation patterns in the nearshore zone, in delineating ecozones as physiographic features preliminary to a state-wide program of environmental design, and forecasting estuarine flushing dynamics. ERTS and complementary aircraft data are meeting real State problems and ERTS-1 imagery is providing an input which cannot economically be obtained in any other way.

ERTS-1 imagery has been less effective than anticipated for shore protection; however, repetitive aircraft coverage is being used in two case study areas to determine the effects of shoreline development on beach erosion.

The investigators note a need for greater intervals of repetitive ERTS coverage, at somewhat higher resolutions and greater speed in delivery of ERTS imagery (NASA) to make the system of delivery of ERTS analytical products operationally efficient within the NJDEP. Many of the products developed would have a greater impact on management decisions if the ERTS system were improved in the above mentioned manner. Additional funding to accelerate computer-based change detection and data display will be requested and are summarized in the following section.

8.0 RECOMMENDATIONS

As a result of the analysis of one year of ERTS-1 imagery, additional requirements have been identified that were not incorporated into the investigation as proposed and funded. New types of information products which will illustrate the value of ERTS data to other coastal states could be prepared and promptly integrated into NJDEP's coastal management program. New Jersey (like other coastal States) has an operational need for information concerning the dynamics of cultural and natural changes in a usable format. It is therefore recommended that the investigation be expanded to incorporate further analyses in the following areas to generate these products.

In June, 1973 the State of New Jersey passed the "Coastal Area Facility Review Act," which puts approximately 25% of the State under environmental regulation (Figure 13). Under this Act, the NJDEP will monitor all major development within the Coastal Area, and enforce the provisions and requirements as written within the Act by permit. Optical and manual analyses of ERTS imagery have been used to detect and monitor coastal zone modifications on the order of two to three acres. Useful products have been prepared manually, but not with the speed required to meet NJDEP operational needs. Experimental comparative analysis (change detection) of ERTS-1 MSS digital tapes could meet these quasi-operational needs. By comparing MSS tapes, resolution cell to resolution cell and plotting cell differences, a machine (map) product can be produced after each orbit illustrating only scene changes. This machine (map) product can then be directly integrated into the regulation and enforcement section of the Coastal Area Act. Developing such products and procedures can benefit all coastal states.

Furthermore, the need for effective management information for shore protection planning has been a problem area addressed as part of this investigation. As was stated earlier, manual and optical analysis of ERTS-1 imagery has not led to the development of additional information. Again, it is suggested that ADP techniques be used in an attempt to delineate the subtle changes that have occurred along the New Jersey shoreline during the past year.

EarthSat now has the capability, in house, to pursue the above tasks. The need for additional analysis has real, practical value to the State since other techniques for gathering such information are less practical economically.

The investigators also recommend that a case study be conducted to assess the utility of ERTS and complementary aircraft data for determining the dilution ratios and dispersion characteristics of sewage outfall plumes. The analysis of ERTS-1 and aircraft imagery for the mapping of ocean outfall plume dispersion would provide information needed by NJDEP for more effective design of ocean outfalls.

A proposal to fund these additional coastal zone management/ environmental protection tasks will be submitted by the investigators.

APPENDIX A
SAMPLE NEW JERSEY ERTS-1 IMAGE ANALYSIS FORM

DATE	ORBIT	TIME	PASS	BAND(S)
10-10-72	1079	15133	2nd - SOUTH	5,7

BRIGANTINE INLET TO ATLANTIC CITY

Nearshore waters are quite turbid as are waters within the sounds and thoroughfares behind the barrier islands. The waters emanating from both Brigantine Inlet and Abescon Inlet at Atlantic City are very turbid as compared to waters offshore and to the south and north. This would indicate that the back bay areas in which all of the sewage outfalls in this area empty, are causing this increased turbidity. An area of less reflectance just south of Atlantic City indicates the separation of water masses from two consecutive tidal changes. In band #5 the wetland areas have less reflectance than the water areas. Just the opposite in band #7.

Turbid waters in this area extend many miles offshore. I would say that the bathing waters along this coastline are definitely being harmed by the sewage effluents in the back bay area. The tidal prism appears to be quite large but the movement of waters once outside the inlets is not very rapid. It is not moving away from the coast rather it is moving along the coast.

Corson Inlet - reflectance of waters in back bay area much less than that to the north or south - much cleaner water. Band of fresh water extending south approximately half way to Avalon. From there on south, waters get more turbid.

Townsend Inlet at Avalon

Band of very turbid water hugging the coast several miles wide all the way down to Wildwood. Great Sound is very turbid. Shoaling observed at Hereford Inlet waters clearer from Hereford to Cape May Inlet. Majority of

tidal flushing from Great Sound must occur at Avalon. Water quite clear from Cape May Inlet S.W. to end of towns bulkhead. Rather a stagnant area along western side of Cape May Peninsula.

Band #7

Wetlands show up very dramatically in this band. Extremely clear image. Shows all developments plotted on 1:40,000 Map of the intercoastal coastal waterway plus some that have been completed since the map was last updated. Shoals observed at Hereford Inlet.

Band #5

Dumping evident S.E. of Delaware Bay entrance. This is Philadelphia dumping zone. Check to see if Philadelphia also dumps toxic chemicals, if not compare reflectance characteristics to that of dumping off North Jersey. Must find a way to distinguish dredge, sewage and toxic chemical dumps.

Avalon and to a lesser degree Wildwood and Atlantic City are always going to be extremely susceptible to strong N.E. storms. However the beaches that run south from each inlet are aligned S.S.E. so they are not taking the full brunt of the storms.

APPENDIX B

COASTAL ZONE REMOTE SENSING BROCHURE

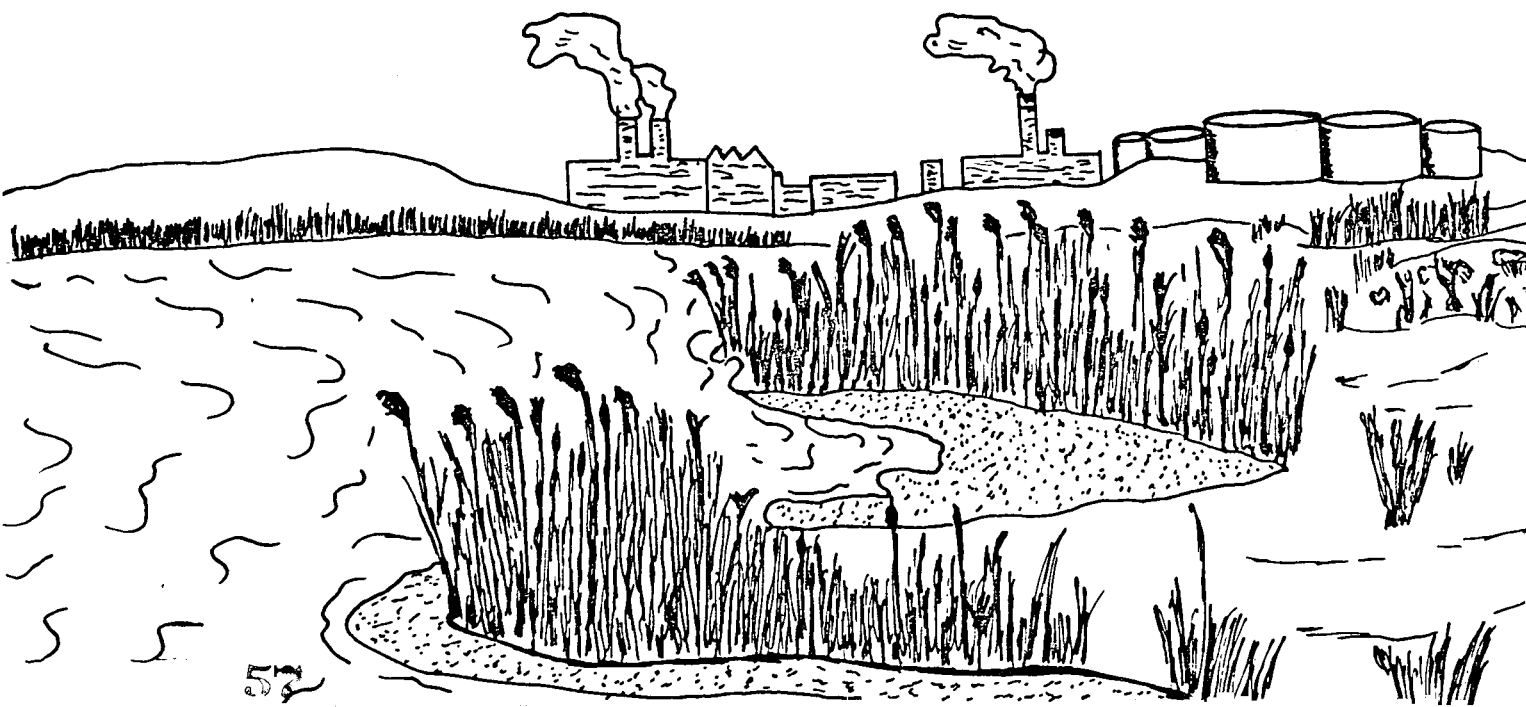
MONITORING COASTAL DEVELOPMENT PRESSURE



AN OVERVIEW OF THE APPLICATION

OF

REMOTE SENSING TECHNIQUES

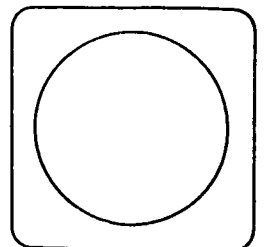


MONITORING COASTAL DEVELOPMENT PRESSURE:
AN OVERVIEW OF THE APPLICATION
OF
REMOTE SENSING TECHNIQUES

by

Donald Garofalo
and
Frank J. Wobber

EARTH SATELLITE CORPORATION
(EarthSat)



May 31, 1973

Gentlemen:

The National Aeronautics and Space Administration (NASA), the New Jersey Department of Environmental Protection and Earth Satellite Corporation (EarthSat), Washington, D.C. are conducting a joint investigation of the application of aerial and orbital remote sensing to coastal zone management in New Jersey.

Coastal areas are difficult for state, county and local agencies to manage because of the complex variety of natural environments and sometimes the scarcity of data required for decision-making. New Jersey's coastal areas are experiencing rapid population growth, and as a result serious land use pressures. Timely data for monitoring man's impact on the coastal environment may be particularly useful for planning and management in your area.

Earth Resources Technology Satellite (ERTS) imagery may be used to address a variety of highly dynamic coastal problems because of its repetitive coverage which makes monitoring on an up-to-18 day cycle possible. Less frequent aircraft coverage which can supplement satellite coverage, is also available.

Applications of aircraft and orbital remote sensing systems may vary from the monitoring and protection of coastal wetlands to the identification of pollution problems. More specifically, remote sensing can be used to provide data useful to applications including:

- Monitoring the affects of dredging and filling on wetlands.
- Identifying the environmental impact of solid waste disposal on coastal water quality and vegetation.
- Predicting urban, recreational and industrial growth trends including direction and rate of growth.
- Limiting the adverse modification of the shoreline caused by erosion and/or sedimentation.
- Detecting sources of chemical and/or thermal water pollution associated with industrial and/or mining activities.

The enclosed booklet briefly describes applications of a variety of aerial and orbital remote sensing systems to coastal problems. Emphasis is given to coastal marine areas but many of the principles apply to the Delaware River and Bay areas. It's purpose is to introduce you to techniques now being evaluated by the Department of Environmental Protection. We hope this information may increase your awareness of the value of remote sensing for rapidly acquiring large quantities of data needed for coastal zone management and planning. As previously cited, this technology also has applications outside of coastal areas and the Department and its consultants will be happy to discuss other potential applications with you.

Imagery which is being catalogued is available at the Department of Environmental Protection in Trenton, New Jersey. Equipment to utilize this imagery is also available. By prior arrangement, the Department's consultants, Earth Satellite Corporation, will try to assist you within the limits of our contract or assist you in applying and analyzing these imagery.

Further information can be obtained by contacting:

Dr. E. Feinberg or Ms. J. Stitt
New Jersey Department of Environmental
Protection
Trenton, New Jersey 08625
(609) 292-2938

Sincerely yours,

Roland S. Yunghans
Environmental Scientist

MONITORING COASTAL DEVELOPMENT PRESSURE:
AN OVERVIEW OF THE APPLICATION OF REMOTE SENSING TECHNIQUES

BY

DONALD GAROFALO
AND
FRANK J. WOBBER

I. INTRODUCTION

Increasing population pressures in coastal zone areas are causing a subsequent increase in residential, recreational and industrial construction. While the coastal counties contain only 15% of the total land area of the United States, 33% of the Nation's population is concentrated there. Urban areas comprise about 10% of the total estuarine zone, and agricultural lands encompass another 13%. Forty percent of all manufacturing plants in the United States are located within coastal counties.^{1/} The Commission on Marine Science reported in 1969 that rapidly intensifying use of coastal lands had already outrun the capabilities of local governments to plan their orderly development and to resolve land use conflicts^{2/}.

Because coastal areas contain complex, fragile and rapidly changing habitats, rapid survey techniques must be used which provide dependable regional management data. Aerial remote sensing provides a tool for synoptic monitoring of the dynamic changes which result from man's activities. This paper categorizes coastal development pressures, discusses some of the environmental data that can be developed from aerial remote sensing for coastal zone management purposes, and suggests remote sensing survey methods which can most contribute

^{1/}The National Estuarine Pollution Study. Report of the Secretary of the Interior to the U.S. Congress; Senate Document No. 91-58; 1970; pp633.

^{2/}Our Nation and the Sea; Presidential Commission on Marine Science, Engineering and Resources, Final Report, January 1969.

to studying coastal areas. It is anticipated that these data will introduce coastal planners to some of the basic but effective uses of remote sensing techniques for monitoring coastal development.

CATEGORIES OF COASTAL ZONE PRESSURE

Environmental pressures in the coastal zone involve a complex interaction of population pressure, building pressure (housing, roads, etc.), mining, dredging and filling, and waste disposal. Each activity may impact the environment and include: (1) vegetation destruction or alteration; (2) erosion; (3) sedimentation of streams and estuaries; (4) landscape scarring; (5) water pollution (chemical or thermal); and (6) degradation of wildlife habitats.

First level development pressures (e.g. urban expansion, and new residential and recreational building) give rise in turn to second level (e.g. road expansion) development (Figure 1). Although the early stages of first level developments are associated with serious environmental degradation, the authors suggest that it is second level development that proves most disastrous to the environment, and the most difficult to manage.

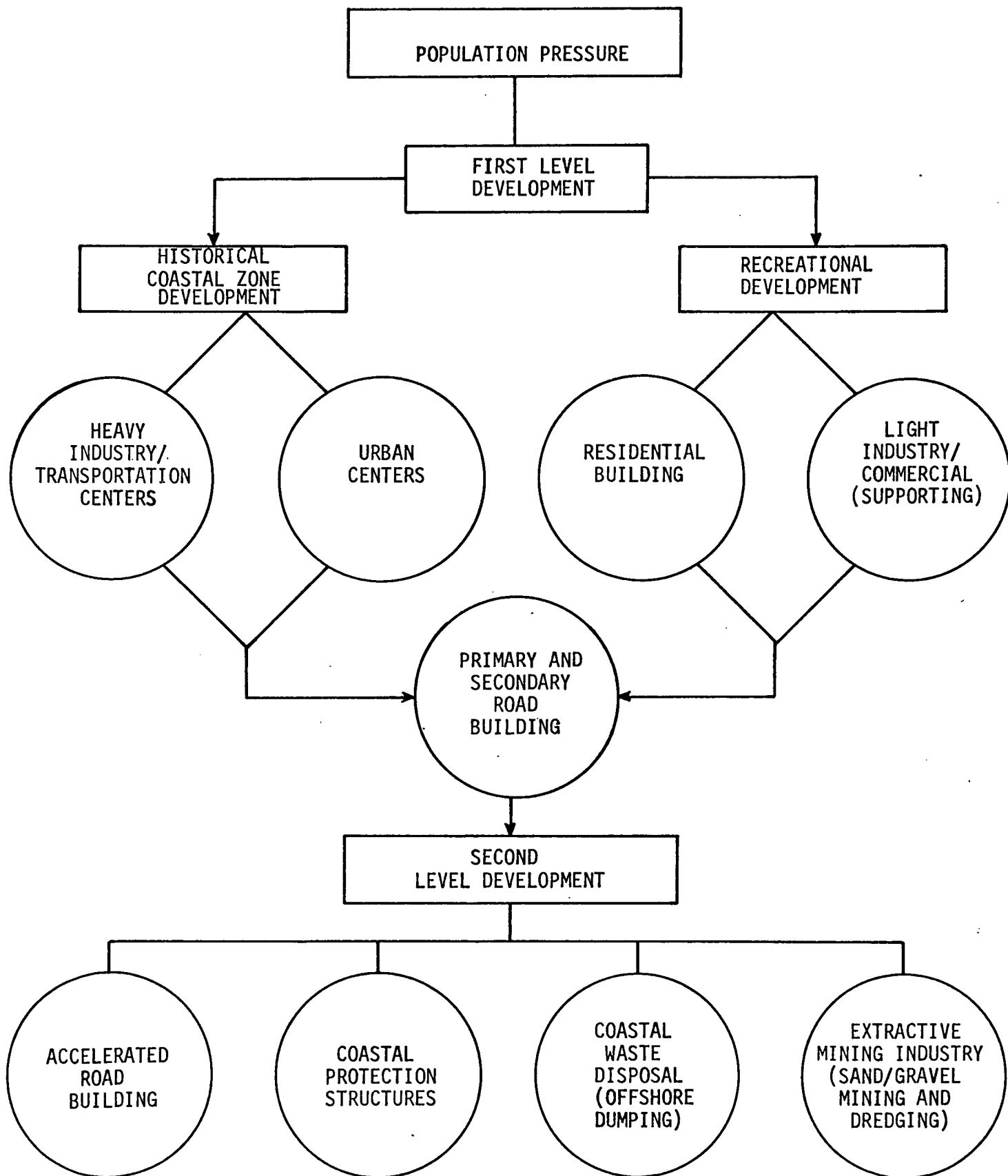


Figure 1: Concept of the two-level coastal development cycle. Population pressures in coastal areas give rise to the historical urban, industrial and recreational development which most readers will recognize. Second level in support of first level development causes environmental deterioration which may be equal to or more serious than first level development.

FIRST LEVEL COASTAL DEVELOPMENT

Population pressure constitutes the most obvious cause for deteriorating coastal environments. Historically, water-based transportation routes (rivers and harbors) lead to urban concentrations with attendant pollution problems and loss of open space. These factors are well understood and will not be discussed further. Attention will, however, be given to more recent coastal pressure including recreational development.

Residential Building

Summer residential building pressure has been common along the coastal zone fringe, i.e. within wetlands and along coastal beaches, for many years.

Analysis of repetitive aerial photographs acquired several years apart illustrate the rapid and dynamic coastal zone growth. (Figure 2) In many areas, wetlands resources are being lost to "Venice-type" housing developments (Figure 3).

Common environmental disturbances associated with recreational construction may include extensive dredging resulting in (1) vegetative destruction; (2) landscape scarring; and (3) accelerated soil erosion. Analysis of 1:12,000 scale natural color and color infrared aerial photography of recreational housing developments reveals that grading during site preparation may often lead to heavy wetlands and estuarine sedimentation (Figure 4). Embankments awaiting bulkheading may remain ungraded and unvegetated for long periods, and regularly contribute major sediment "pulses" into wetlands, coastal streams and ocean inlets. Following construction of "Venice" developments dredged channels may, because of their orientation not receive the tidal flushing necessary to cleanse them of pollutants which remain in situ and stagnate.

The scope of the problem can better be appreciated by analyzing high altitude aircraft (1:120,000 scale) imagery, and orbital (ERTS-1) photography.

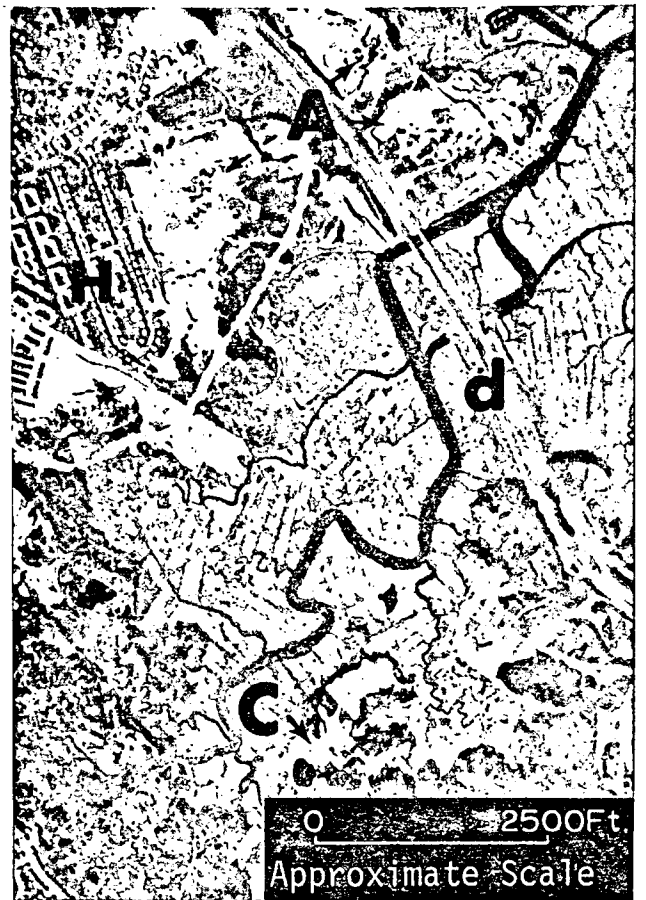


Figure 2: Comparative aerial photography is useful for determining area changes e.g. new road construction, new surface mining operations, and rate of growth and direction of residential expansion. By analyzing comparative 1953 (left) and 1969 (right), aerial photographs it was found that residential housing (H) expanded. A mine which was not in existence in 1953 (C) is present in the 1969 photograph and development and expansion of mining in area (A) took place. Construction of the roadbed for the Garden State Parkway is underway in 1953 (g) and the completed road can be seen in the 1969 photo of the same area (d).

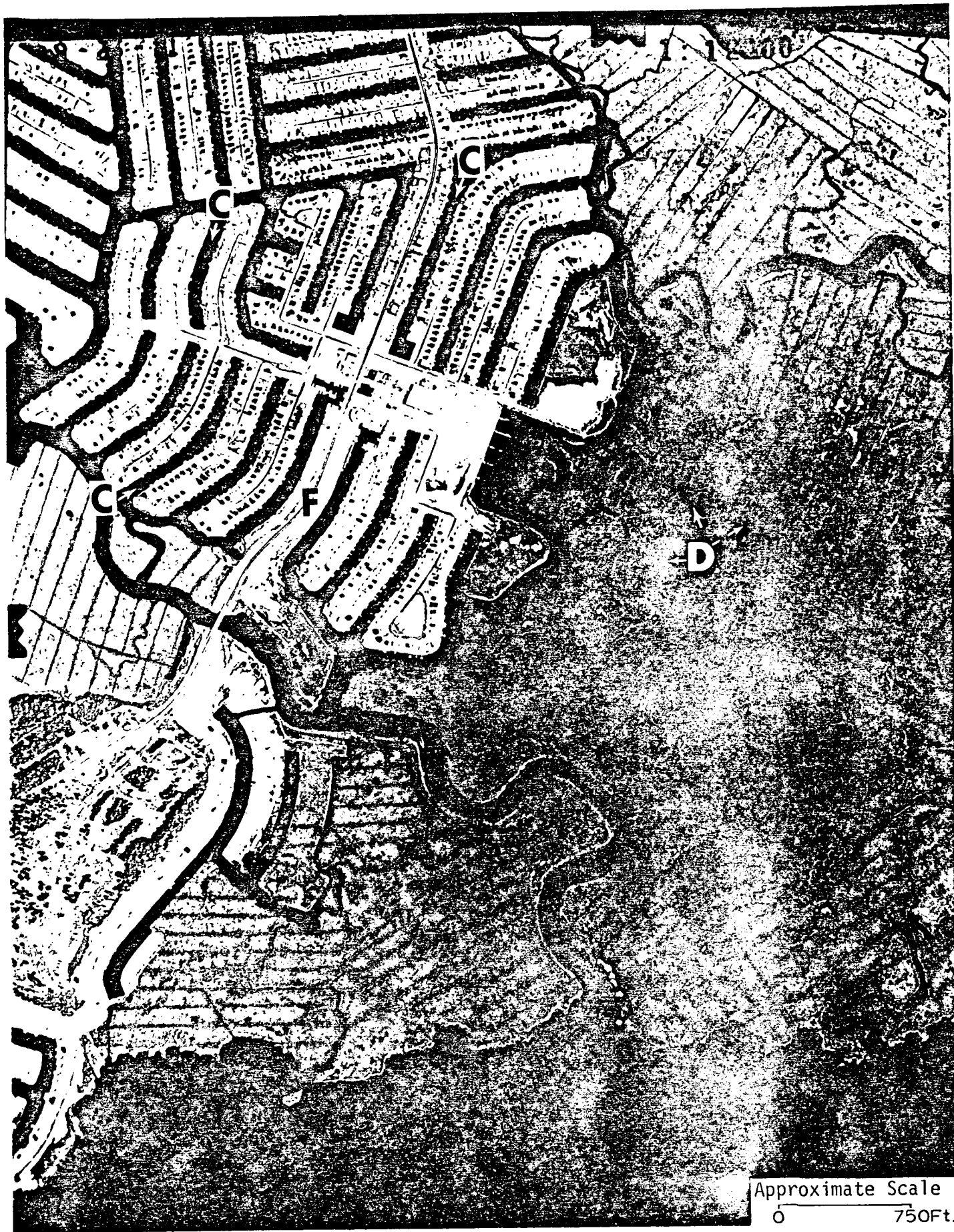


Figure 3: "Venice-type" housing developments are now common in numerous coastal areas. Channels (C) often do not receive the necessary tidal flushing to keep them clean. This panchromatic photograph shows a "Venice-type" housing development in New Jersey which is adjacent to a ditched saline wetland. Wetland ditching (D) is used to control mosquito populations, i.e. by minimizing the standing pools which constitute suitable breeding grounds. Unprotected bare areas (e.g. F) contribute sediment to coastal waters. Dredging activities associated with channel digging for these developments disturb and frequently completely destroy marine benthic communities.

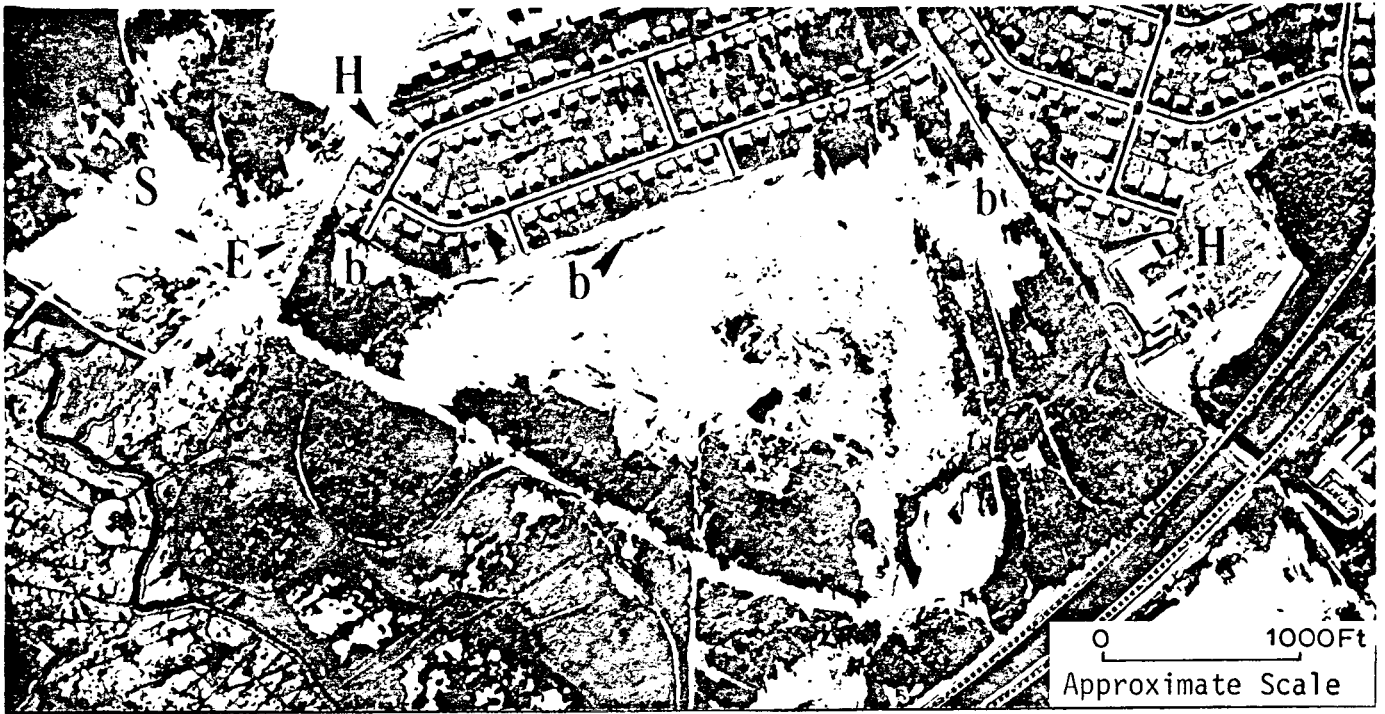


Figure 4: This black and white reproduction of a color infrared aerial photograph shows housing developments (H) located adjacent to coastal wetlands. A sharp topographic break (b) separates lowlands from uplands. New grading during final building site preparation will produce large sediment influxes (E) which will be spread downslope and then by streams (S) into coastal waters. Precarious embankments of weakly consolidated clays, sands and silts may remain ungraded and unvegetated long after building and rapid erosion with attendant sediment pollution is common.

Source: New Jersey Department of Environmental Protection

Analysis of ERTS-1 multiband imagery (Figure 5) shows that bare ground areas can be readily detected (and inventoried) in coastal areas in the visible red (0.6 to 0.7 micrometer) band. Bare ground areas include construction sites, and major dredge and fill operations. Large coastal streams can be identified using the near infrared (0.8 to 1.1 micrometer) band; a semi-quantitative index of the potential threat of sediment pollution can be determined by using the proximity of bare ground to coastal streams. Once areas are located using ERTS imagery, they can then be selectively monitored from aircraft.

Industrial Development

Industrial development here emphasizes facilities close to major coastal urban centers (iron and steel, and petroleum industries.) That remote sensing techniques can be useful for monitoring pollution from most (if not all) heavy industry in coastal areas is reasonably accepted. Petroleum refineries have been identified as posing a particularly serious threat to nearshore and offshore environments (Figure 6). Damage to oil storage tanks, which are inadequately revetted can result in serious oil spills which are in turn, discharged into coastal waters. Aerial photography at scales from 1:5,000 to 1:60,000 is useful for identifying potential spill sites. Thermal infrared images (8-14 micrometer range of the electromagnetic spectrum) are useful for discriminating subtle water temperature differences indicative of industrial thermal outfalls, oil spills and clandestine liquid waste disposal sites.

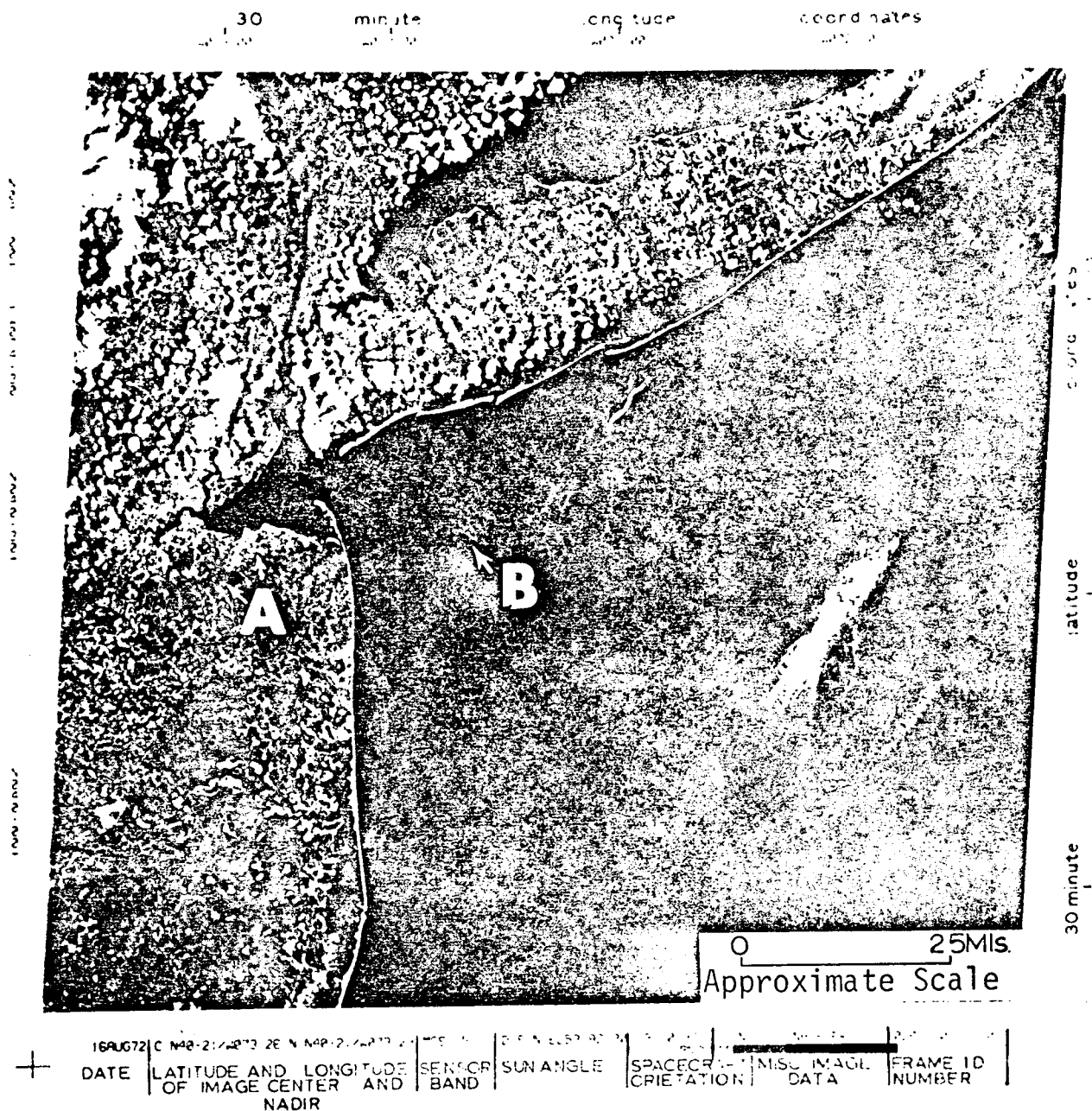


Figure 5: This is an ERTS-1 multispectral scanner image (0.6 to 0.7 micrometers) showing the northern half of coastal New Jersey and Long Island. Bare ground areas (A) (> 25 acres) can be readily identified using this band. An inventory of bare ground in/or adjacent to coastal zone areas can be conducted using this imagery; an index of areas of potential stream sedimentation can be determined (based on the proximity of bare ground to streams). Coastal currents can also be monitored using ERTS-1 imagery; this data can be useful for planning the location of coastal structures in order to minimize coastal erosion and aid in beach accretion. Sewage dumping sites (B) can also be identified.

Source: NASA

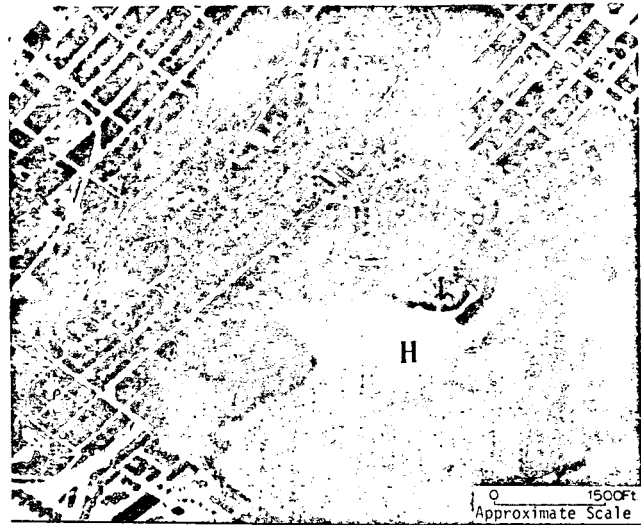
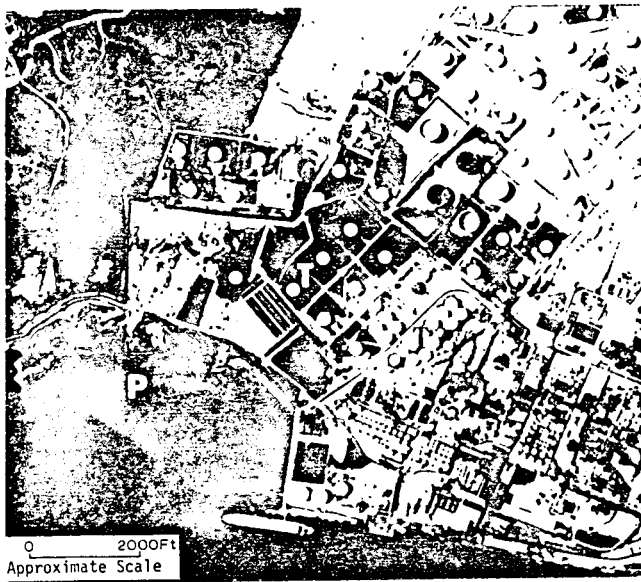


Figure 6: Heavy industrialization in coastal areas to include refineries, and power plants continues to threaten delicately balanced coastal zone environments. Panchromatic, natural color and color infrared aerial photographs at scales from 1:5,000 to 1:60,000 have been used to identify potential petroleum spills i.e. sites where protective revetments have not been constructed or where inadequate retaining structures exist. The photo at left is a black and white rendition of a color infrared aerial photograph of petroleum storage tanks (T) and industrial waste ponds (P) on the Delaware River, New Jersey. Wastes are being discharged directly into the river at (P); some storage tanks adjacent to the river bank present a serious oil spill threat, and should be monitored on a regular basis. Thermal imagery (right) shows a power generating plant (I) situated along the bank of a large river (Hunters Point, San Francisco, California). Dark toned areas are relatively cool compared to warm (light toned) areas. The image shows a thermal discharge (heated effluent H) entering the river from the power generating plant. Such imagery can also be used for locating sewage or fresh water outfalls.

Source: New Jersey Department of Environmental Protection (left) EarthSat (right)

SECOND LEVEL RESPONSE TO DEVELOPMENT PRESSURE

Extractive Industries

Extractive industries including sand, gravel and clay pits, and dredging operations are essential to "feed" new coastal development. These industries are sufficiently critical that the authors suggest that special zoning of their operations may provide the primary control to reduce the destruction of coastal environments.

The environmental effects of dredging and filling are complex but reasonably understood. Less well appreciated are clay, sand and gravel operations. Several mining operations in coastal areas have been intensively studied using 1:12,000 scale color infrared and natural color photography. Typical environmental pressures exerted on the wetlands by the mining industry and identified using remote sensing technology include: (1) destruction of valuable wetland resources by removal of overburden; (2) rill, sheet, and gully erosion; (3) landscape scarring following mining; and (4) stream sedimentation (Figure 7).

Using aerial photographs estimates of mine size and mine production can be computed by comparing updated photos with historical photographic coverage.



Figure 7: This black and white reproduction of a natural color aerial photograph (left) emphasizes the utility of aerial photography for locating sediment outfalls resulting from a variety of man's activities in the coastal zone. Sediment plumes can be readily distinguished at (A). A comparative black and white reproduction of a color infrared aerial photograph (right) facilitates identification of plant communities; its poor water penetration makes it unsuitable for pinpointing stream sedimentation. Sediment pollution at (S) is not evident on the color infrared photograph. Surface clay mining (M) can be easily identified using both natural color and infrared 1:12,000 scale photography.

Expanded Road Networks

The need for mobility and access to coastal areas necessitates the development of extensive highway networks in support of secondary development. Primary and secondary roads are often elevated (usually on dredge and fill materials) to avoid inundation by tidal or flood waters. Where drainage pipes are constructed under roadways to facilitate free tidal flow, wetlands habitats are altered, e.g. shifts from high to low productivity wetlands species occur (Figure 8). In addition, dredging and filling associated with road construction contributes large volumes of sediments which serve to raise and indirectly drain and destroy wetland areas. Coastal highway construction limits wildlife mobility, increases sedimentation, limits tidal flow, reduces water quality by eutrophication, and retards the spread of nutrients.

Historical 1:24,000 scale aerial photographs are commonly used for planning highway routes but are less effectively used for studying the environmental changes following highway construction (Figure 9). For example, recent surveys of the Garden State Parkway indicate that Phragmites communis has crowded out nutrient-producing species in strips paralleling the highway. Analysis of the historical aerial photographs shows that little change has taken place with respect to morphology of tidal stream channels. While vegetation changes near the highway occurred, wetland vegetation, which is several hundred yards from the highway does not appear to have been adversely affected by the highway's construction.

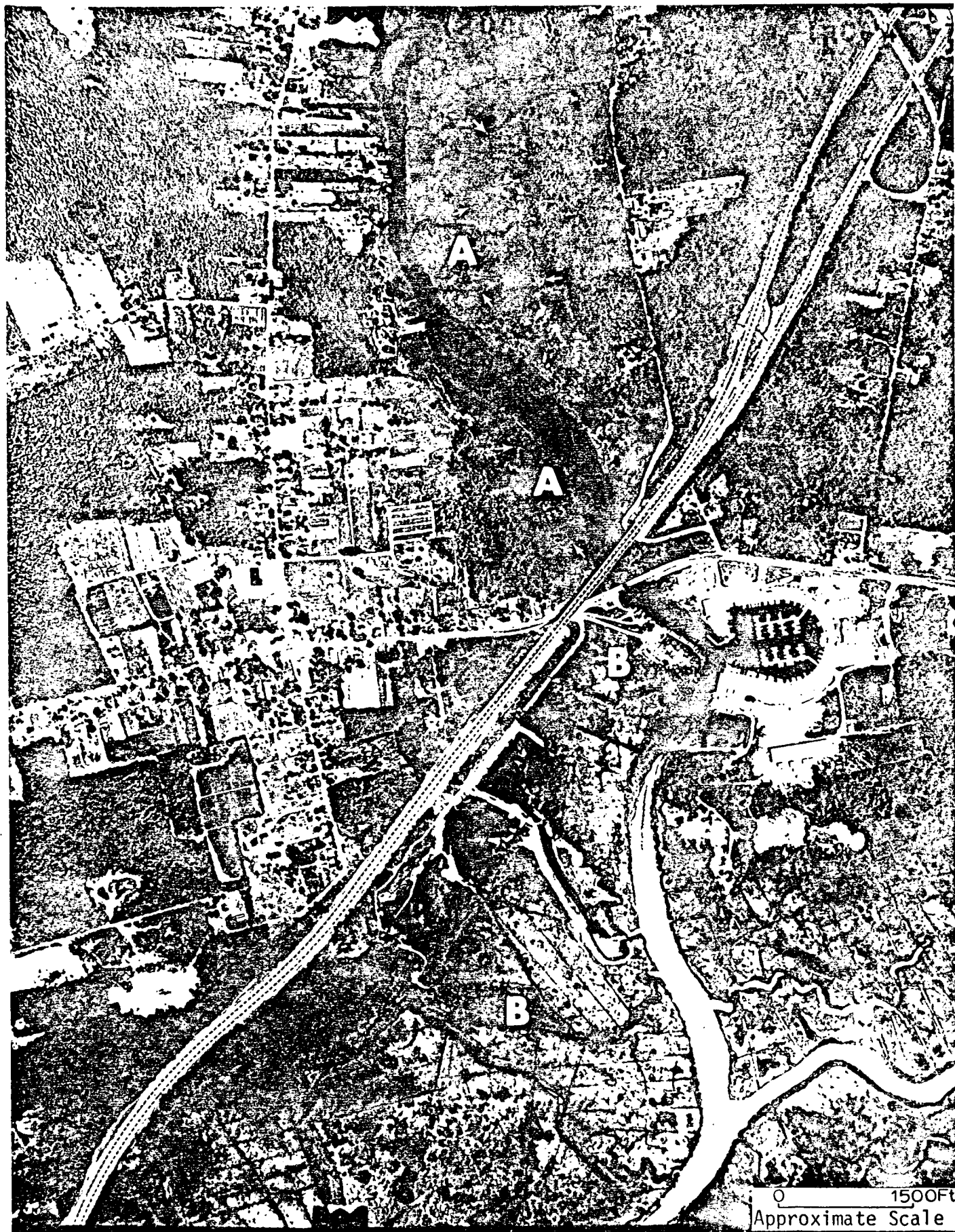


Figure 8: This black and white reproduction of a color infrared aerial photograph shows the north to south-flowing Bass River near New Gretna, New Jersey. The Garden State Parkway crosses the river in a northeast/southwest direction and U.S. Route 9 crosses the river near the center of the photograph. Interpretation of the original color infrared aerial photography at a scale of 1:12,000 reveals a dramatic shift in wetland communities. Wetland vegetation just north of the highways (A) consists predominantly of Typha spp. (Cattail) and Scirpus americanus (American three-square). Just south of the highway (B) wetland vegetation shifts to Spartina alterniflora (Salt marsh cord grass) and Spartina patens (Salt meadow grass). Both are high nutrient producing wetlands species. Area (A) supports a large muskrat population (white dots and arrows). A shift from desirable to undesirable wetland plant communities has resulted from placement of the highway which acts as a partial barrier to the tidal flow.

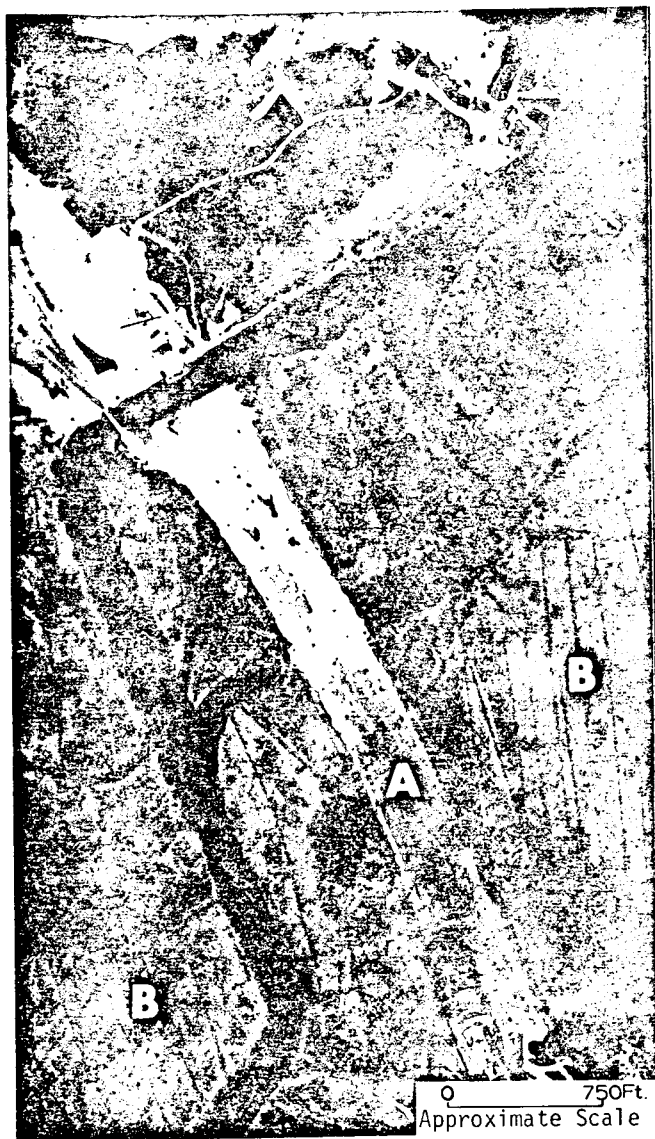


Figure 9: Black and white aerial photographic coverage (left) shows the 1953 roadbed (A) of the Garden State Parkway under construction through ditched saline wetlands (B). Roadbeds in this area are built on fill-material and elevated to prevent inundation. A transition zone between wetland and dryland has been artificially formed along the roadbed, and Phragmites communis (common reed) is replacing other wetland species. Phragmites communis was not growing along the highway in 1953; the adjacent 1969 (color infrared) aerial photograph shows a wide band of Phragmites communis (C) along both sides of the highway. Color infrared aerial photographs at 1:12,000 scales can be useful for identifying and anticipating the extent of wetlands damage from construction activities.

Paved and built up areas increasingly encroach upon coastal environments. Although tabulated statistics including linear miles of highway, highway surface and highway width are usually available to planners, such tabular data fail to provide important information, e.g. where the highway is located in relation to waterfowl habitats, valuable wetland resources, or natural areas worthy of preservation.

High altitude 1:120,000 scale color infrared photography (Figure 10) can be used to estimate paved area (acres) versus: (1) high nutrient producing wetlands; (2) undeveloped areas of coastal beaches and their natural access routes or (3) wildlife refuges or other delicately balanced ecological areas. Such data can provide indices for state or local officials to be used in environmental impact statements.

Shore Protection Structures

In order to preserve unstable shore areas, jetties and groins may be used to control beach erosion or aid in beach accretion. Unpredictable coastal current systems produce unanticipated results. For example, (Figures 11 and 12) in order to keep the Cape May Inlet open, two large jetties were built, which extend outward from and perpendicular to adjacent barrier beaches for distances of approximately 500 to 1,000 yards respectively. The inlet is regularly dredged. Sediments from the north are transported by long shore currents and trapped by the northernmost Cape May Inlet jetty. This sand supply which would otherwise reach the beach just southwest of the inlet has been interrupted by this man-made barrier; this has resulted in erosion



Figure 10: High altitude 1:120,000 scale aerial photography provides a rapid overview of regional environmental pressures in coastal areas. This single frame covers a ground area of approximately 48 square miles. High altitude color infrared aerial photography is particularly useful in coastal zone areas because of its haze penetration capability and undisturbed and built-up areas are sharply contrasted. Disturbed sandy areas are imaged in bright (light) tones. Information which can be obtained from this photograph includes: (1) encroachment of housing developments (A) on wetland areas (B); (2) areas of recent disturbances, in this case, surface mining (S); (3) areas of high (D) or low (E) density highway networks; (4) coastal sedimentation and beach erosion (H); and (5) area of light industrialization (G).



Figure 11: This black and white copy of a color aerial photograph shows a large sediment plume (S) moving into the Atlantic Ocean from the Cape May Inlet. As the plume exits from the inlet, it curves toward the east and then rotates in a counter clockwise movement so that some of the sediment is deposited along the beach to the northeast of the jetty. The plume would be moving in a northerly direction because of an ebb tidal stage and/or high river runoff into Delaware Bay. This plume will most likely curve in a SW direction as often as it curves in a NE direction. Also, the sediment load consists of a "fine" particle load and contributes little to beach replenishment. However, materials within a plume such as this usually are much more polluted than the nearshore waters and impact heavily on water quality. Such data is useful to coastal engineers responsible for placement of future groins or jetties in the area.

of the beach to the west^{2/}.

Coastal Waste Disposal

Coastal wetlands are too often considered useless areas; open garbage dumps and landfills are common in and around wetlands (Figure 12). Sanitary landfills include careful preparation of the fill area, control of water drainage and then employment of heavy equipment to spread and compact waste in alternate layers with dirt. Less care is sometimes given the immediate areas surrounding the landfill.

An environmental impact study of an existing solid waste disposal site within a wetland area using natural color and color infrared aerial photography at scales of 1:12,000 to 1:120,000 has been conducted. The study reveals that aerial photography can be used to identify and monitor: (1) vegetation destruction at disposal sites; (2) erosion and stream sedimentation resulting from runoff from the site (3) water color differences indicative of water changes and (4) site capacity.

^{2/} EarthSat is presently analyzing spacecraft imagery from the ERTS-1 satellite for the purpose of studying coastal dynamics along the coast of New Jersey. Coastal outfalls, currents, sediment plumes and other phenomena will be studied for improving New Jersey's coastal management program. The placement of coastal structures and the effects of existing structures on coastal processes are two of the many problems now being studied.

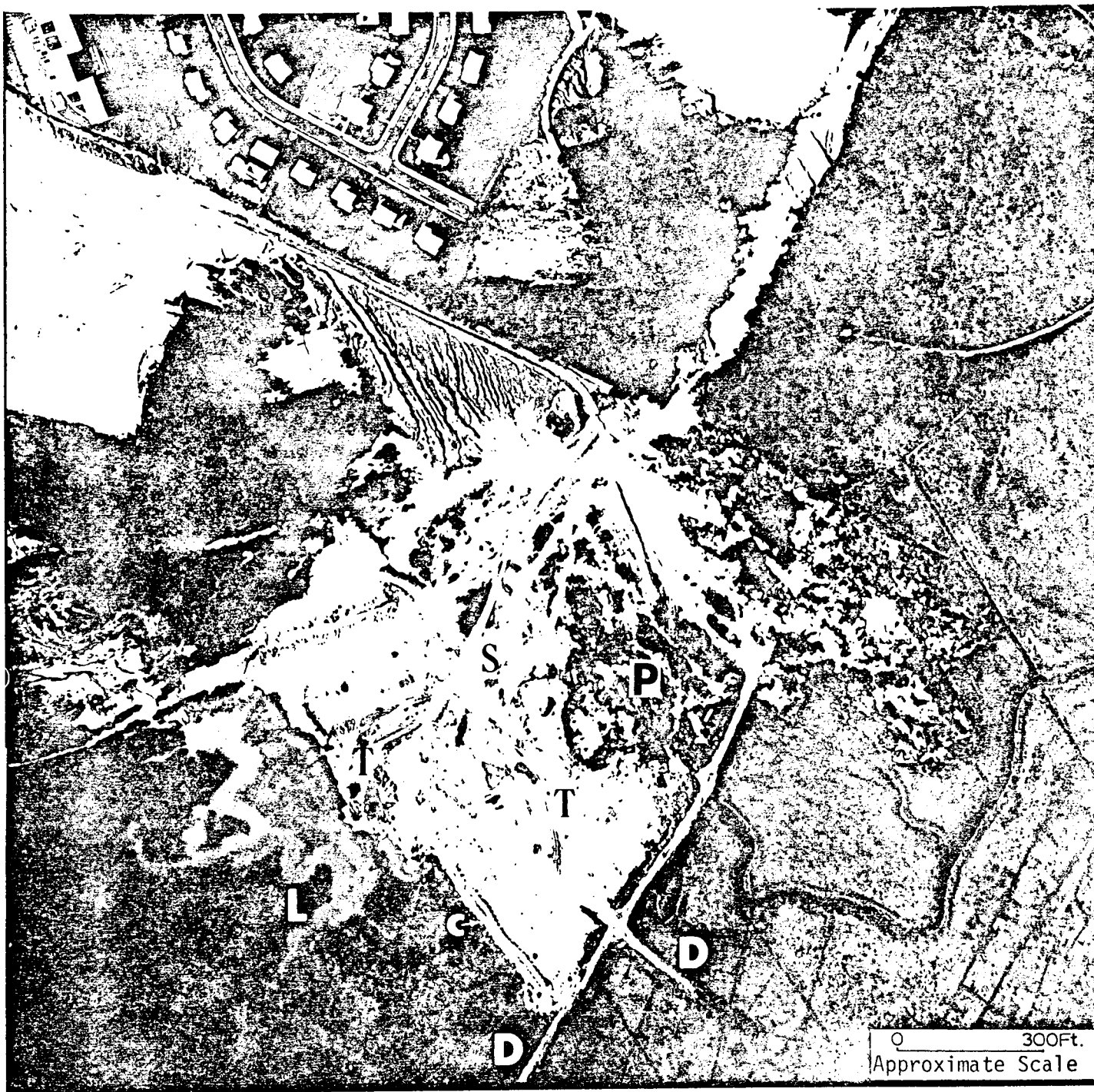


Figure 13: This black and white copy of a natural color aerial photograph shows an active landfill (solid waste disposal) site (S). Cover material can be identified at (C). The tracks (T) of truck traffic can be seen; one direction of site growth can be ascertained from filling of outlying ditches (D) along the sites perimeter. Phragmites communis (P) has begun to establish itself at the site in response to the filling of a wetland area. Heavy stream sedimentation (and probably leachate) can be seen to the lower left (L).

Remote Sensing Systems Useful for Coastal Environmental Protection

A wide variety of remote sensing records have been reviewed to determine the system (platform and band) which can most immediately contribute to studying the response of coastal environments to development pressure. The analyses which have been completed are summarized for ease of reference in Figure 14.

Natural color and color infrared aerial photographs of 1:120,000 scale or larger have the most immediate value for monitoring coastal environments.

Once a coastal data base is established using remote sensing records from aerial platforms, increasingly smaller scale imagery (orbital platforms) can be utilized to maintain it.

For highly developed and generally stabilized (little or no new buildings) or recreational areas, high altitude aerial color photography supported by moderate to low altitude thermal surveys will be most responsive to coastal environmental monitoring needs. In areas of rapidly changing or accelerating second level development when close surveillance of natural environments is essential, high altitude surveillance supported by selected low altitude color and color infrared photography provides the greatest flexibility for coastal planning and management. There are few advantages - including costs - to using black and white coverage; acquiring data comparable to that available from color infrared photography most often requires more costly low altitude coverage.

Although significant information is available from orbital platforms, and particularly for rapid computation of areal changes, further studies of

FIGURE 14: Remote Sensing Applications to Monitoring Selected Coastal Pressures and their Environmental Impact

SENSOR AND SCALE TESTED										ENVIRONMENTAL IMPACT
Panchromatic 1:24,000						•	•	•		
Panchromatic 1:63,000						•	•	•		
Panchromatic 1:250,000						•	•			
Natural Color 1:12,000		•	•		•	•	•	•	•	
Natural Color 1:120,000		•			•	•	•	•	•	
Natural Color 1:250,000							•	•		
Color Infrared 1:12,000		•	•			•		•	•	
Color Infrared 1:120,000		•				•		•	•	
Color Infrared 1:250,000						•		•	•	
Thermal Infrared Imagery				•						
ERTS-1 Multispectral Imagery			•			•	•			
SELECTED COASTAL PRESSURES										
Solid/Liquid Waste Disposal		•		•	•	•	•	•	•	
Coastal Protection Structures							•			
Mining, Dredge and Fill		•	•		•	•	•	•	•	
Pollution from Existing Industrial Plants		•		•	•				•	
Construction Sites		•	•			•	•	•	•	
Access/Highway Construction		•	•			•	•	•	•	
		Wildlife Habitat Destruction	Escapement and Steep Slope Formation	Water Pollution - Thermal	Water Pollution - Chemical	Landscape Scarring	Sedimentation of Water Bodies	Erosion/Bare Ground	Vegetation Destruction or Alteration	

the utility of ERTS-1 for coastal planning are required. The close integration of high altitude aircraft coverage with coverage from orbital platforms will continue to be essential for protecting coastal environments.

CONCLUSIONS

Deterioration of coastal environments is increasing in response to population pressure. Remote sensing can provide essential management data rapidly, and facilitate studies of spatial relationships.

Small scale aircraft and spacecraft imagery provides useful synoptic data for establishing broad indices of environmental quality and for evaluating environmental pressure in response to changing land use. Low altitude aerial photography can be used to conduct detailed environmental studies, once problem areas are identified from high altitude platforms. Natural color and color infrared aerial photographs of 1:120,000 scale or larger have immediate value for assessing the impact of coastal activities on the environment.

For planning purposes, remote sensing provides a permanent pictorial record of conditions at a given moment in time, which can later be used to monitor changes which are continually taking place. Basic decisions related to managing coastal zone resources can benefit from the overview which aerial and orbital remote sensing records provide.

APPENDIX

CATEGORIES OF COASTAL ZONE
PROBLEMS WHICH MAY BE STUDIED

Some of the coastal counties operational problems which annually involve decision-making related to coastal construction and environmental protection, include the following:

A. Shoreline Construction Projects

- The placement of groins, jetties, seawalls, and bulkheads
- Siting of coastal structures such as outfall pipes

B. Dredging Projects

- The location and maintenance of dredge channels for inland water traffic
- The placement of fill with minimum damage to shore areas

C. Coastal Erosion

- Loss of barrier beach or wetlands beach areas
- Changes in coastal shore morphology

D. Coastal Dumping

- Solid waste disposal in coastal areas
- Sewage dumping at offshore sites
- Dredge spoil disposal

E. Environmental Effects of Coastal Projects^{1/}

F. New Urban, Recreational and Industrial Construction

- Displacement of virgin coastal lands by newly constructed facilities

^{1/} Shoreline construction projects have sometimes not been related to their potential for ecological damage because of inadequate data and funds to conduct environmental impact studies.

SUMMARY OF GOALS AND OBJECTIVES

- To monitor the affects of dredging and filling on wetlands
- To identify the environmental impact of solid waste disposal on coastal water quality and vegetation
- To predict urban, recreational and industrial growth trends including direction and rate of growth
- To limit the adverse modification of the shoreline caused by erosion and/or sedimentation
- To detect sources of chemical and/or thermal water pollution associated wth industrial and/or mining activities

COASTAL APPLICATIONS OF REMOTE SENSOR
RECORDS AND SOURCES

Remote Sensing Record	Principal Coastal Applications ^{1/}	Primary Sources
Black and white aerial photography	Computing coastal erosion and changes Examining storm effects Coastal landform analysis Water current studies	NOS, NASA, USGS, State of New Jersey Private Firms
Color infrared aerial photography	Coastal vegetation mapping	NASA, USGS, State of New Jersey
Black and white infrared aerial photography	Shoreline delineation Determining changes in coastal landforms	USGS, NOS, NASA
Color aerial photography	Water penetration studies (study of submerged features) Water current studies Dye tracer movement studies Examining storm effects	USGS, NASA State of New Jersey
Multiband aerial photography	Water penetration studies (study of submerged features) Water depth determinations Vegetation mapping Water current studies	NASA Private firms
Satellite photography	Examining large scale coastal processes Regional coastal landform analysis Monitoring turbid water plumes Monitoring nearshore sediment transport	NASA

^{1/} Routine planimetric mapping not referenced.

(Continued)

Remote Sensing Record	Principal Coastal Applications	Primary Sources
Infrared imagery and radiometer data	Thermal effluent (pollution) dispersion studies Water current studies Tidal flushing	NASA Navy Coast Guard
Multispectral imagery	Coastal phenomena identification and discrimination Water depth mapping Automated terrain classification by computer processing	NASA
Radar imagery	Examining coastal drainage features Regional coastal terrain analysis	NASA Navy

GENERAL REMOTE SENSING PRODUCTS^{1/}

Products which may be prepared manually from aerial and orbital remote sensing records include:

- Line-Map Products
- Annotated Line Maps or Photomaps
- Overlays
- Sketches/Cross Sections/Block Diagrams^{2/}
- Annotated Enhanced Images^{3/}
- Tabular Listings^{4/}
- Reconnaissance and Detailed Interpretation Reports

^{1/}Basic manually-derived products, by category. Some secondary products (e.g. line maps and overlays) will be prepared by combining graphic (line) maps and ERTS-A image products to draw conclusions. These combinations are not listed.

NOTE: In some cases, selective overlays of information might be manually acquired from imagery. Combining these "slices" could produce a higher order of information.

^{2/}To represent concepts developed from image analysis

^{3/}Polaroid or other photo-copies from Addcol or Digicol-type devices on which annotations will be placed directly

^{4/}Based on computations or summaries of data derived from imagery

APPLICATIONS JUDGED^{1/} COMPATIBLE WITH SATELLITE AND AIRCRAFT

LEVELS OF DETAIL

SOURCES	SCALE	TYPE	APPLICATIONS EXAMPLES
NASA	Small Scale	ERTS orbital imagery	<ul style="list-style-type: none"> • Observe the effects of coastal structures • Large scale current patterns and turbidity • Major shoreline changes • Offshore dumping patterns • Region-wide waterway or off-shore power plant site planning
NASA	Intermediate	High altitude aircraft photography/imagery	<ul style="list-style-type: none"> • Repetitive coverage of specific coastal test sites for detailed temporal dynamics • Assess effects of currents and waves on structures • Major effects of dredging • Effects of extreme events, e.g., coastal oil spills • New dredging activity
NJDEP and many Federal agencies EarthSat light aircraft coverage Many private flying firms NJDEP helicopter	Large Scale	Low altitude aircraft photography/imagery (plus ground truth)	<ul style="list-style-type: none"> • Detailed information on environmental impact of out-fall pipes, dredge dumping, etc. • Nature of building size and type • Dredging in state versus private wetlands

^{1/} SOURCE: F. J. Wobber, based on evaluation of Gemini and Apollo imagery and comparable aircraft data.

EARTH RESOURCES TECHNOLOGY
SATELLITE PROGRAM (ERTS)

The Earth Resources Technology Satellite (ERTS) program is a first step in the merger of space and remote sensing technologies into a demonstration system for management of Earth's resources. To establish the feasibility of these techniques, NASA has launched an experimental satellite (ERTS-1) into orbit: ERTS-2 will be launched in 1973. (Figure 1) Each will:

- Acquire multispectral images of the earth's surface and transmit this raw data through ground stations to NASA Goddard Space Flight Center for data processing and for conversion into black-and-white photographs, color photographs and computer tapes.
- Collect environmental data from remote, earth-based instrument platforms and relay this information to the data processing center at Goddard for final processing and dissemination to investigators.

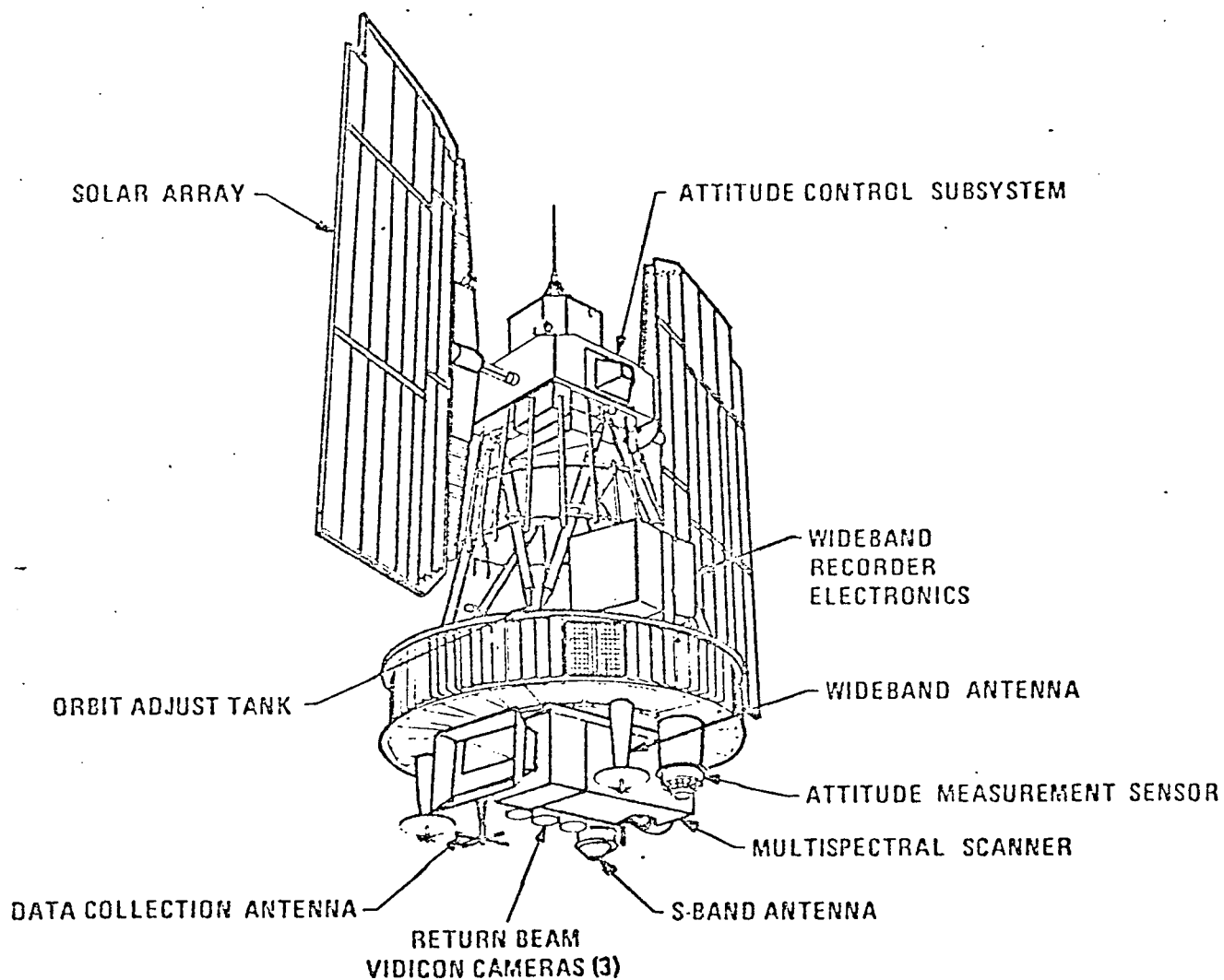


FIGURE 1: ERTS SATELLITE

ERTS SENSORS

Return Beam Vidicon Camera (Figure 2)

The Return Beam Vidicon (RBV) camera system operates by shuttering three independent cameras simultaneously, each sensing a different spectral band in the range of 0.48 to 0.83 micrometers. Since these are visible wavelengths, the RBV is operated only in daylight. The viewed ground scene, 115 by 115 miles in area, is stored on the photosensitive surface of the camera tube and, after shuttering, the image is scanned by an electron beam to produce a video signal output.

Multispectral Scanner (Figure 3)

The Multispectral Scanner (MSS) is a line scanning device which uses an oscillating mirror to continuously scan perpendicular to the spacecraft velocity. Six lines, with the same bandpass, are scanned simultaneously in each of the four spectral bands for each mirror sweep. Spacecraft motion provides the along-track progression of the six scanning lines. Optical energy is sensed simultaneously by an array of detectors in four visible spectral bands from 0.5 to 1.1 micrometers for daylight operations of ERTS. Continuous strip imagery is transformed to framed images with a 10 percent overlap of consecutive frames and an area coverage approximately equal to that of the RBV images at Goddard Space Flight Center.

Data Collection System (Figure 5)

The Data Collection System (DCS) obtains data from remote, automatic

^{1/} Appendix I contains information on the Types and Utility of Remote Sensing with brief descriptions of the applications of the principal sensors.

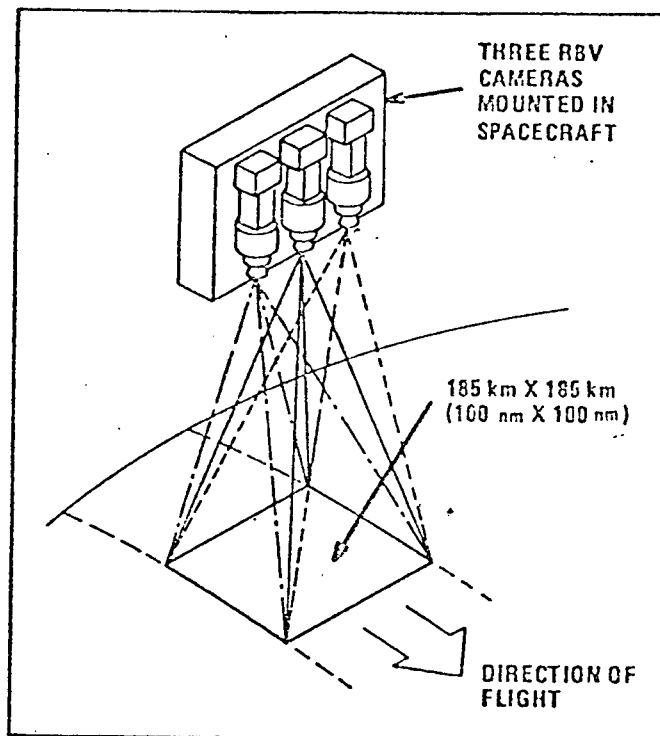


FIGURE 2: RBV Camera Head Orientation

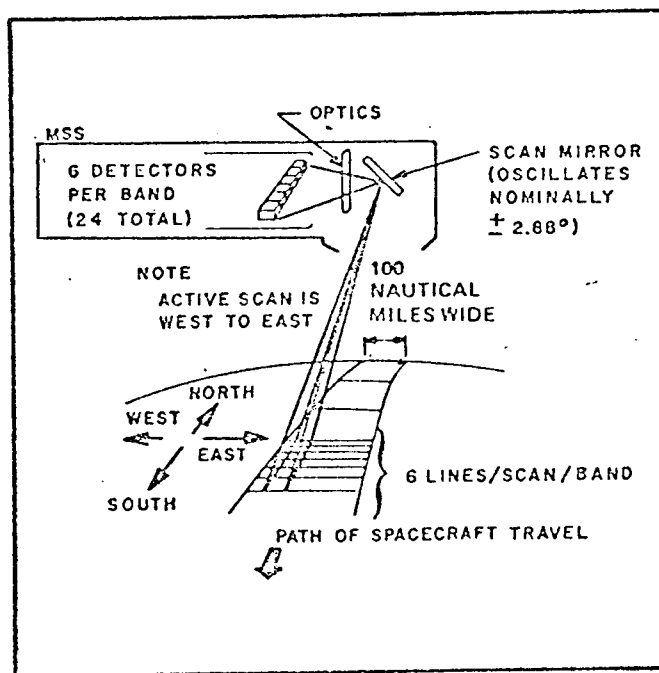


FIGURE 3: MULTISPECTRAL SCANNER

data collection platforms, and relays the data via the satellite to ground stations whenever the ERTS spacecraft is within range of any platform and any one of the ground stations. Each DCS platform collects data from as many as eight sensors, supplied by the investigator, sampling such local environmental conditions as temperature, stream flow, or soil moisture. Data from any platform is available to investigators within 24 hours from the time the sensor measurements are relayed by the spacecraft.

ERTS Sensors & Spectral Bands

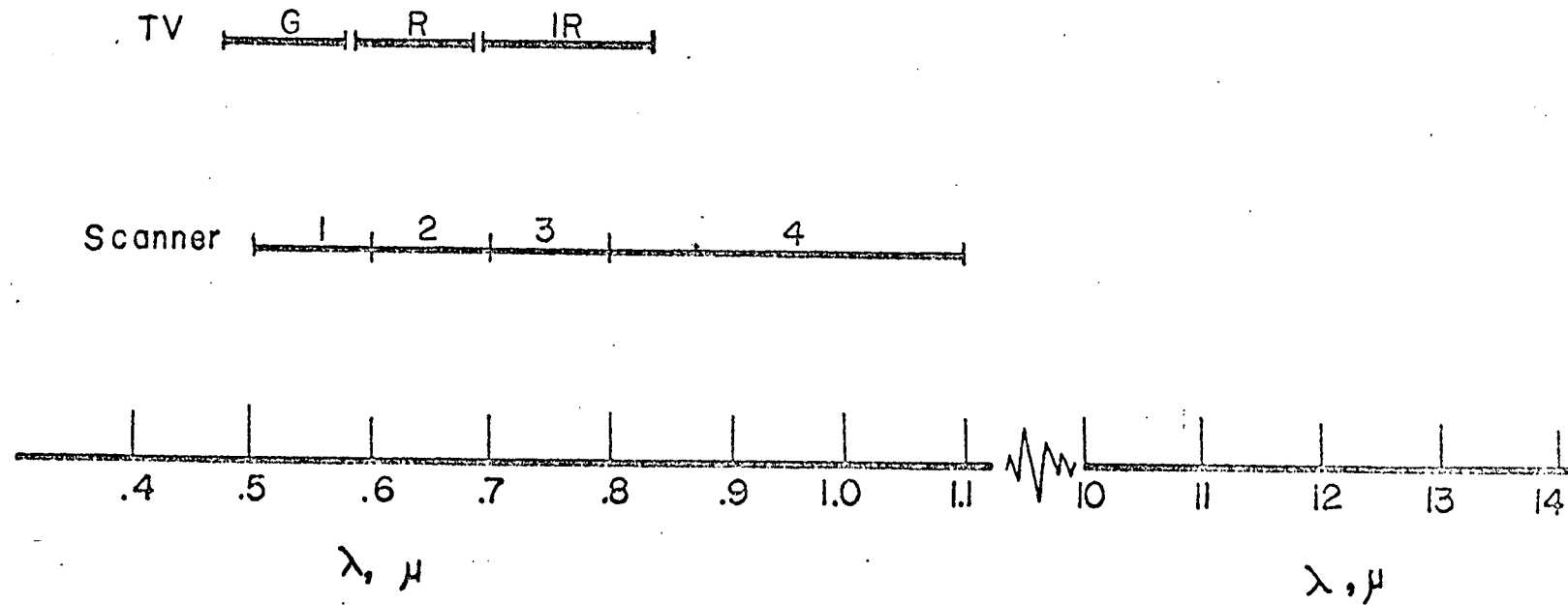


FIGURE 4

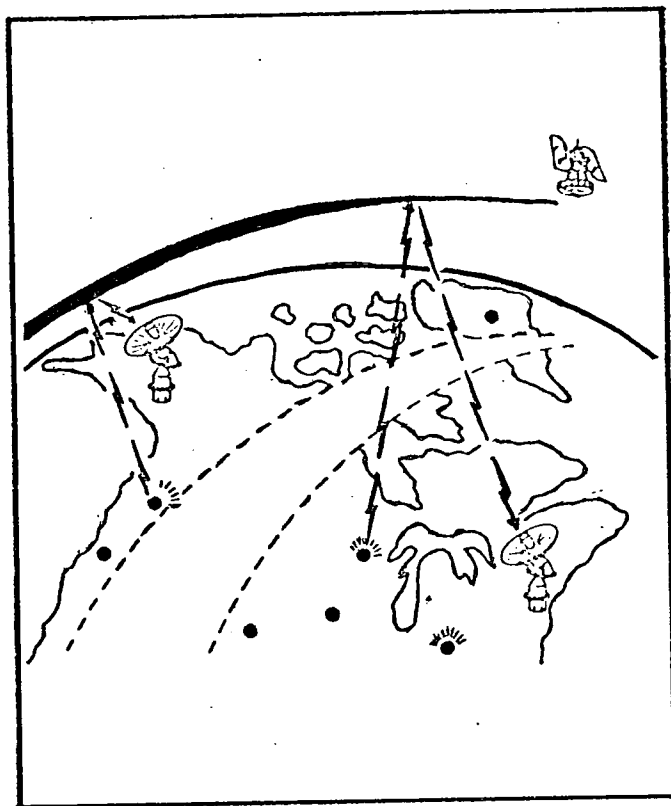


FIGURE 5: Data Collection System

THE AIRCRAFT UNDERFLIGHT PROGRAM

The NASA Aircraft Program has produced a large quantity of experimental remote sensing data. It is the tool used by NASA and other Federal agencies to develop remote sensor systems and to define their application. The aircraft provides a flexible platform from which to assess the performance and utility of developmental sensors. The aircraft observations program in the recent past, has been conducted by NASA in cooperation with Federal user agencies, for qualified investigators. NASA uses the aircraft program to develop new remote sensor systems, and NASA and other Federal agencies subsequently use these systems for multidisciplinary research.

INTEGRATED REMOTE SENSING APPROACH

The use of a multilevel approach to the study of coastal problems will lead to the most productive results.

ERTS

- identifies immediate problem areas
- monitors overall coastal environments
- provides repetitive coverage
- provides data on major circulation, erosion, and sedimentation patterns

AIRCRAFT

- supplement the repetitive coverage from ERTS
- ensure efficient and effective use of low level aircraft
- provide higher resolution data for studying specific problem areas

GROUND TRUTH INVESTIGATION

- verify specific problems and solutions to problems as determined from aircraft and spacecraft
- can rapidly check anomalous conditions
- can increase the confidence of data derived from image analysis
- are necessary to validate results
- provide essential background data in support of image analysis from historical and routinely collected data

TYPES AND UTILITY OF REMOTE SENSING

Advantages of Remote Sensing

- Aerial vantage point provides a synthesis unavailable from field observations, and supplements them.
- Can provide a record with sufficient geometric fidelity to serve as a map substitute.
- Images often have more detail than maps at comparable scale.
- High density medium for information storage, and retrieval with proper analysis.

PHOTOGRAPHY

- Black and white panchromatic photographs are used widely for coastal mapping, and most related problems of sedimentation and erosion.
- Color photographs are advantageous for investigating underwater features and current patterns.
- Black and white infrared photographs sharply define the land-water interface (shore) and are useful for shoreline changes.
- Color infrared (false color) photographs are used to discriminate coastal vegetation and to observe submerged features in very shallow water.

MULTISPECTRAL IMAGING

- Multispectral photographs or images of specific portions of the visible spectrum.
- Particular utility for studies of circulation dynamics in turbid water.
- Blue Band (.4-.5 μm)
 - deepest penetration in clear water
 - utility decreases in turbid water
 - gives some measure of atmospheric haze
- Green Band (.5-.7 μm)
 - deepest penetration in mean coastal water
 - not affected by atmospheric haze
- Red Band (.6-.7 μm)
 - poorest water penetration
 - very useful in highly turbid water
- Near IR Band (.7-1.1 μm)
 - no water penetration
 - excellent shoreline definition

- A multispectral system with narrow bandpass widths (.025-.050 μm) ranging from the upper blue through the lower red portion of the visible spectrum can be very useful where there are large changes in water mass characteristics in the area.

THERMAL INFRARED IMAGERY

- Water and land bodies emit infrared radiation in proportion to their temperature.
- On positive prints or transparencies, light tones are warm relative to dark (cool) tones.
- Applications of thermal infrared imagery include detection of:
 - Discharges and dispersion of relatively cool groundwater outfalls
 - Discharges and dispersion of relatively hot waters, e.g., power plant outfalls.
 - Temperature differentiated currents, and upwellings
 - Oil pollution

RADAR IMAGERY

- Active remote sensing device, i.e., provides its own source of energy rather than relying on solar energy or emitted energy from terrain.
- All weather capability.
- Used for mapping coastal landforms, including mud flats and beach ridges.
- Limited for coastal studies because of (a) low spatial resolution and (b) inability to provide data concerning turbidity, water depth or current patterns.

SATELLITE IMAGES

- Low resolution may act as a filter which accentuates larger sized phenomena.
- Large area coverage provides a synthesis for monitoring major dynamic coastal processes including coastal circulation, tidal flushing and patterns of coastal erosion.
- To date, Gemini and Apollo photographs were limited in value because repetitive coverage was unavailable. ERTS fills this gap.

APPENDIX C .

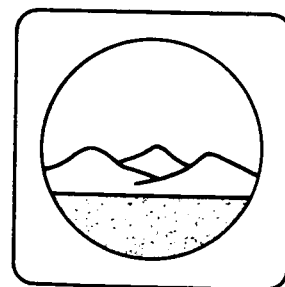
REGIONAL ECOLOGICAL MAPPING BROCHURE

110-a

REGIONAL ECOLOGICAL MAPPING AND ANALYSIS OF NEW JERSEY RESOURCES

**INFORMATION PRODUCTS PREPARED FROM ANALYSIS OF
EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS) DATA**

**FOR THE NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION**



EARTH SATELLITE CORPORATION
GEOSCIENCES AND ENVIRONMENTAL APPLICATIONS DIVISION
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OUTLINE

REGIONAL ECOLOGICAL MAPPING AND ANALYSIS OF NEW JERSEY RESOURCES

- 1.0 INTRODUCTION AND BACKGROUND
- 2.0 LAND RESOURCES ANALYSIS
- 3.0 THE ECOZONE CONCEPT
- 4.0 UTILIZATION OF ECOZONES
- 5.0 ROLE OF ERTS DATA IN ECOZONE DELINEATION
- 6.0 DESCRIPTION OF ECOZONES AND SUBUNITS
 - 6.1 Statewide Ecozone Map of New Jersey (1/500,000)
 - 6.2 Coastal Area Map of New Jersey (1/250,000)
- 7.0 APPLICATIONS OF ECOZONE MAPS

This document provides background information to the NJDEP for the evaluation of one of a series of products derived from the NASA-funded ERTS-1 experiment SR-304.

- Requirement for environmental impact statements to evaluate in detail the impact of proposed development activities upon the surrounding land or waterscape. This policy recognizes that man's activities may significantly alter natural ecosystems. The effects of these activities must be carefully evaluated to minimize environmental damage.

Each of these expressions ultimately influences the land use planning process, both at the local (community and county) and regional (state and interstate) level. The successful implementation of land use planning to balance competing uses requires that attention must be directed to the nature and distribution of the natural and cultural resources within planning units. The need for recognizing the special attributes of resource complexes as they affect the planning process was recently acknowledged by Governor Cahill in his Third Annual Message (January 9, 1973):

The manner in which land is used is an important determinant of the quality of the environment, particularly in New Jersey, the most densely populated state in the nation. Certain environmentally critical areas within the State deserve and require a special degree of care. These environmental regions transcend political boundaries so that shared governmental responsibility for charting the future of these areas is required. The State must help to ensure that these critical lands are used in environmentally sensible ways. By virtue of their unique qualities, they are important to the people of the entire State, not just to those fortunate enough to reside close to them.

2.0 LAND RESOURCES ANALYSIS

Sound land use planning requires accurate, up-to-date resource information presented in a usable and easily understandable format. Since planning units are often extensive in surface area, land resources evaluation may be facilitated by visualizing the total resource complex from a regional perspective.

Environmental impacts and interactions which are not apparent at a local scale can often be detected and analyzed from a regional vantage point. Regional relationships may also be monitored temporally from this perspective to assess dynamic alterations of a nature too subtle for detection within a short time framework.

Resource interpretation may effectively progress from regional to local analysis. Identification of environmental problems at a regional level can aid in the establishment of priorities for detailed analysis.

Localized analysis can yield more specific information on the composition of resource complexes, e.g., the identification of the major species types within a forest area. The quality or vitality of the resources and the recognition of environmental impacts which may have been introduced through improper resource use (e.g., overcultivation of areas having dry, sandy topsoil) may be determined.

Recognition of the constituents of resource complexes is a necessary step in identifying (for example) unique natural areas for

preservation. Identification of environmentally impacted areas enables the resource manager and environmental planner to introduce measures (possibly through litigation) to ensure the future protection and restoration of damaged resource areas.

3.0 THE ECOZONE CONCEPT

A regional perspective has proven valuable in the recognition of naturally occurring zones of ecological homogeneity: ecozones. An ecozone is defined as a regional area characterized by homogeneous interrelationships of soils, landforms, vegetation, geology, drainage, and land use.

Major delineation criteria for ecozones are:

- (1) regional areal size
- (2) homogeneous physiography
- (3) homogeneous natural vegetation, and
- (4) homogeneous land use (natural or cultural)

That an ecozone must be regional in area is an overriding constraint in delineation. For example, unique vegetative communities (e.g., cedar swamps) do not qualify as ecozones unless they have large regional extents. A preliminary, minimum ecozone size is 200 square miles (700 square kilometers).

Physiographic units are distinguished by having characteristic sets of landforms, soils, drainage and topography and appear to constitute ecological units of a scale which is too gross even for regional resource management. Such ecologically unique areas as the Coastal Zone, the Pine Barrens, and the Agricultural Belt (which borders the Pine Barrens on the west) all belong to the same physiographic province (Atlantic Coastal Plain) and physiographic section (Northern Embayed Section).^{2/} Some clearly unique and homogeneous areas (e.g., the Pine Barrens) are not recognized physiographically even at the subsection level. Significant regional ecological differences, which exist within physiographic units, must be considered for constructive environmental planning. This suggests that other considerations are essential for a working ecozone concept.

Vegetation often exerts a strong influence on land use. For example, vegetation frequently controls wildlife habitat, affects recreation potential, or impedes the conversion of an area to more intensive types of land use (e.g., dense forest is difficult to clear for agricultural use). Frequently, regional units appear to qualify as ecozones on vegetative characteristics alone. Within areas of similar physiography, vegetation serves as criteria for the further definition of ecozones.

Culturally modified areas with high urban densities constitute cultural ecozones. The importance of native vegetation, landforms,

^{2/} William Thornbury, Regional Geomorphology of the United States.

etc., has been significantly altered and/or reduced in these areas. The northeastern urbanized corner of New Jersey, in combination with urban areas along the Delaware River, constitutes a cultural ecozone. Natural areas of low intensity land use (e.g., wilderness forest) may qualify as natural ecozones depending upon their extent and internal homogeneity.

Further subdivisions within ecozones can be isolated and identified to acquire environmental information of greater detail. These units would be utilized to extract and store information used for local land management and detailed site selection.

4.0 UTILIZATION OF ECOZONES

Ecozones have been described as broad-based, regional subdivisions with natural limits or boundaries (e.g., Pine Barrens, Coastal Zone, etc.). The value of using natural subdivisions in a land resources evaluation is multifold:

- Ecozones represent real environmental subdivisions, rather than arbitrary units selected to conform to county or state boundaries. Artificial units are not as useful for regional planning purposes in that natural resources (and, therefore, the management of these resources) tend to transcend political boundaries.
- Ecozones can aid in the identification of critical coastal areas for priority resource analysis.
- Recognition of ecozones also enables the definition of interfaces where interactions between ecologically diverse elements may occur (e.g., urbanized coastal fringe area vs. wetland).

5.0 ROLE OF ERTS DATA IN ECOZONE DELINEATION

A small scale synoptic view is required for the recognition and delineation of regionally similar land areas. Such areas cannot be effectively identified using large scale (e.g., 1/20,000) imagery due to the limited area covered by a single photograph. Small scale composites of these photographs (mosaics) can be assembled. However, uniformity of photo tone, image displacement in edge matching and a variety of other problems reduce the effectiveness and convenience of such mosaics.

In contrast, one ERTS image (covering approximately 10,000 square miles) affords an overview of the terrain complete with uniform, reliable tonal signatures and greatly increased convenience in analysis. Differences in surface resource use may be identified utilizing a mix of ERTS Multispectral Scanner (MSS) bands. Extensive areas which exhibit similar tones, patterns and texture are generally areas of consistent land use and resource composition. The approximate boundaries of these regional areas can best be identified through systematic ERTS analysis. Larger scale imagery may be required for the resolution of indefinite boundaries or areas of apparent ecozone overlap.

6.0 DESCRIPTION OF ECOZONES AND SUBUNITS

6.1 Ecozone Descriptions

The ecozones detailed below have been mapped on the accompanying map (1/500,000 scale). Ecozone names are derived from prominent place

names or dominant water or landscape characteristics. The ecozones are defined on the basis of uniform land use, image characteristics and land-forms as identified from the analysis of ERTS imagery. Brief descriptions appear as follows for each of the New Jersey ecozones.

- I. COASTAL ZONE: area of coastal land and water including the wetlands, barrier islands, bays and inlets which are directly affected by coastal processes
- II. PINE BARRENS: level area of contiguous forest cover with low intensity land use and a marked absence of agriculture
- III. LAKEWOOD: forest area with extensive residential and commercial development; mixed land use
- IV. VINELAND: area of mixed agriculture and forest; remnant forests line dendritic drainageways
- V. AGRICULTURAL BELT: area of intensive farming with small forest woodlots and some residential and urban development; includes most of the best farmland in New Jersey
- VI. URBAN AND INDUSTRIAL ZONE: industrialized, densely urbanized areas of intensive land use
- VII. PIEDMONT PLAIN: area of mixed, moderate-yield cropland and urban land use with scattered, forested traprock ridges
- VIII. HUNTERDON PLATEAU: area of curvilinear forested ridges and cleared valleys with relatively low yield cropland
- IX. UPPER DELAWARE RIDGE AND TERRACE: area of rolling terrain in which forest cover and agricultural use predominate
- X. KITTATINNY MOUNTAIN: a steep series of heavily forested ridges of low intensity land use
- XI. KITTATINNY VALLEY: rolling topography consisting of forested ridges and valleys with small lakes dotting the landscape; farming is practiced on cleared valley floors

- XII. HIGHLANDS: rugged, partially forested, mountainous area containing numerous lakes; valleys have been cleared for agricultural use
- XIII. WASHINGTON: level valley enclosed by Highlands Ecozone; rural land use; intensive agriculture predominates
- XIV. PASSAIC BASIN/WACHUNG MOUNTAINS: urban land use and forest cover predominate in this relatively level river basin ringed by a lightly developed area of forested, traprock ridges
- XV. RIDGEWOOD: urban land use and forest cover predominate in this area; topography is similar to the Piedmont Plain Ecozone

6.2 Coastal Area Subunit Description

Within the Coastal Area significantly different areas of resource and land use occur. These areas have been delineated from analysis of ERTS imagery as ecozone subunits. They appear on the accompanying map (1/250,000 scale). For completeness, their descriptions are supplemented with background information and are presented below. The subunits are principally derived from the Coastal Ecozone. The area of coastal influence includes portions of the Pine Barrens and Lakewood Ecozones.

- A. Saline Wetlands: wetland marsh areas predominantly composed of saline vegetation; they characteristically occur in the lee of barrier bars and islands, and on the coastal edge of the mainland.
- B. Brackish/Freshwater Wetlands: areas of predominantly brackish-freshwater marsh vegetation which commonly occur in the estuaries of coastal rivers and streams and along the northern edge of the Delaware Bay.
- C. Barrier Bars and Islands: sandy areas which occur off-coast and are characterized by the development of beaches, back-shore dunes, offshore bars and littoral hooks and spits; these areas contain a unique form of xerophytic vegetation which serves to stabilize dunal formations.

- D. Developed Wetlands and Islands: areas of intensive development (e.g., Atlantic City) may be detected on the ERTS imagery and are recognized as unique subunits; Areas of moderate intensity or less than extensive development were not delineated.
- E. Intra-Coastal Water: area protected by offshore barrier islands in which confluence of freshwater and saline ocean water occurs.
- F. Coastal Influence Area: upland area adjacent to coast; land use is influenced by its coastal location; contains resorts, residential communities, and service industries.

7.0 APPLICATIONS OF ECOZONE MAPS

- As natural (e.g. real) land use planning units.

Regional areas having uniform physiographic, vegetative, and land use characteristics should logically be managed as integral units. They should not be subdivided by arbitrary, artificial boundaries and subjected to a variety of (conflicting) different uses.

- As a framework for evaluating the ecological vitality of the landscape

Assessment of pollution, environmental degradation, plant succession, etc., can be recognized through an analysis progression from regional (general) to local (detailed) analysis.

- As a means for identifying critical environmental areas which require protection

For example, prime agricultural land, coastal marshland, and natural areas (e.g., pinelands) may be most easily recognized on the regional level as comprising unique ecozones.

APPENDIX D

COASTAL ZONE SURVEILLANCE BROCHURE

OUTLINE

COASTAL ZONE SURVEILLANCE PROGRAM

- 1.0 INTRODUCTION AND BACKGROUND
- 2.0 METHODOLOGY
- 3.0 PRODUCT DESCRIPTION
- 4.0 POTENTIAL APPLICATIONS
- 5.0 DEPARTMENT EVALUATION PROCEDURE

This document provides background information to the NJDEP for the evaluation of one of a series of products derived from the NASA-funded ERTS-1 experiment SR-304.

COASTAL ZONE SURVEILLANCE PROGRAM

1.0 INTRODUCTION AND BACKGROUND

Dredging and filling of coastal wetlands and nearby upland areas occur randomly in isolated and often unobserved locations. Effective regulation of coastal development must be supported by the enforcement of legislation which restricts uncontrolled development. The destruction attendant to rapid clandestine dredging can only be diminished through prompt detection and reporting to the appropriate State agencies.

State officials cannot normally expect to monitor all coastal areas with equal intensity utilizing ground checking procedures. Remote sensing techniques (including the use of repetitive satellite coverage) can provide an economical, comprehensive and relatively unbiased means of detecting and assessing the extent of new dredging, dredge spoil disposal, and land clearing activities.

The results of the study described herein indicate that sequential ERTS imagery can be utilized to periodically identify significant areas of disturbance within the coastal zone. The initial effort has served as a basis for structuring a coastal zone surveillance program to periodically supply environmental information to the NJDEP.

2.0 METHODOLOGY

Synoptic, repetitive coverage of the Atlantic Coast of New Jersey provided by ERTS-1 imagery has been used to develop a program of wetlands and coastal zone surveillance. Comparisons of coastal areas were made between recently acquired ERTS images and frames obtained on earlier dates. Systematic comparisons of the same areas are utilized to identify where changes have occurred.

Land clearing as well as dredging and filling operations result in a highly altered land surface. This surface will frequently exhibit unique ERTS image characteristics, enabling the differentiation of natural cover (e.g. marsh land and forest land) from altered areas (e.g. land under development). Because of the relatively low resolution of the ERTS system, altered areas must usually cover at least two or three acres before they can be consistently resolved. Those land use changes which are detected represent major land or waterscape alterations, the location of which should be known by the NJDEP.

3.0 PRODUCT DESCRIPTION

The results of ERTS analysis for coastal surveillance are presented in the following product formats:

- ERTS Photo Base Map: Areas of suspected alteration are annotated on a small scale ERTS photo base map of the New Jersey coastal zone. This map serves to indicate the general position and relative concentration of suspected areas on a regional basis. It can be used to broadly plan field inspection activities. A comparison between observed alterations in the coastal zone and existing permits can be rapidly accomplished.
- Photoquad Sheets: The detailed location of each suspected alteration is annotated on New Jersey photoquad sheets (dated April, 1972) which correspond to standard 1:24,000 USGS topographic map sheets. These photoquad sheets will serve as a working guide to direct wetlands inspectors or other personnel to the particular sites of suspected alterations.

The sample wetlands surveillance report which accompanies this description contains a relatively small number of detected land surface alterations. These changes are summarized in Table 1 with ERTS data when they were first observed. It was recognized at the outset that the likelihood of detecting changes (mainly dredge-and-fill operations) within wetlands areas would be minimized due to the moratorium on development in effect since 1970. A dramatic reduction in the frequency of dredge-and-fill operations has been confirmed through ERTS analysis.

The seasonal nature of large scale land development and construction is an important factor affecting the necessary frequency of observations. Such activities are frequently begun during the spring and summer months, and occur least commonly during the winter months. Since the interval of ERTS analysis for these investigations was October through early April, it is reasonable to expect that little clearing, filling or new construction would have been initiated. Further comparisons of ERTS imagery acquired during the spring and fall will reveal whether the pace of development has, in fact, accelerated.

During the interval of ERTS analysis (October 10, 1972 to April 7, 1973), a small number of changes were detected. Several of these changes were observed on upland areas adjacent to wetlands within the "coastal area".^{1/}

It appears that the moratorium on wetlands development has shifted the focus of development from the wetland environment to the relatively undeveloped upland forested zone adjacent to it. Monitoring of land use change throughout the "coastal area" can provide data necessary for assessment of relative developmental pressures. Equally significant, this technique may provide in-

^{1/} Defined by the State in the Coastal Protection Act as constituting a unique, irreplaceable resource worthy of protection and balanced development.

TABLE 1

SUMMARY OF ERTS-1 IMAGERY DATES
FOR WHICH COASTAL ZONE SURVEILLANCE CHANGES WERE OBSERVED ^{1/}

<u>SITE #</u>	<u>PHOTOQUAD</u>	<u>1972</u> <u>10 October</u>	<u>25 January</u>	<u>1973</u> <u>13 February</u>	<u>7 April</u>	<u>13 May</u>
1	Point Pleasant		NC	NC	X	NC
2	Toms River		X	(Area Widened)	NC	(Area Expanded To South)
3	Toms River/ Keswick Grove		X	NC	NC	NC
4	Forked River		X	NC	NC	NC
5a	Ship Bottom/ Forked River		NC	NC	NC	X
5b	Ship Bottom/ Forked River		X	NC	NC	NC
5c	Ship Bottom/ Forked River		NC	NC	NC	X
6	Oceanville		X	NC	NC	(Forest Cleared From Interior Of Area)
7a	Marmora		X	NC	NC	NC
7b	Marmora		X	NC	NC	NC
7c	Marmora		X	(Slight Enlarge- ment)	NC	(Possible Slight En- largement)
7d	Marmora		NC	X	NC	NC
8	Marmora		NC	(Ice Cover)	X	NC

^{1/} X= First ERTS-1 imagery date for which significant change detected.

NC= No change since previous date.

Other minor changes noted in parentheses.

formation useful for implementing the "Coastal Zone Act".

4.0 POTENTIAL APPLICATIONS

The following applications of the Wetlands Surveillance reports are anticipated:

- Activities of wetlands inspectors can be complemented in terms of more frequent data collection, increased detection of illegal operations, and increased confidence in the permit control systems.
- The degree of land use change can be assessed by tabulating changes detected on ERTS imagery over periods of months or years.
- Changes in environmental quality can be measured. Conversion of wetlands to industrial, urban and residential use cause primary and secondary changes in environmental quality. Indicators of change could be expressed as, for example, acreage lost per jurisdiction (e.g., county) per year, or percent wetland area lost per year.
- Areas experiencing high developmental pressures can be identified. Areas with concentrated development are likely candidates for closer ground inspection and increased control. Such concentrations will be apparent on the ERTS photo base map.
- Implementing the "Coastal Zone Act". Monitoring of development within the area covered by the Act is required if the State is to achieve the balanced land development which will provide for both ground and protection of the environment.

5.0 DEPARTMENT EVALUATION PROCEDURE

Each observed alteration has been annotated on the small scale ERTS New Jersey base map and summarized in Table 1. To facilitate Department evaluation of the surveillance report, the following materials are provided for each suspected alteration: (1) photoquad sheet, marked with location of each area; and (2) surveillance report sheet for each observance, with capsulized description of area and suspected change.

It is recommended that these items be supplied to wetlands inspectors^{1/} for their evaluation. Once each site has been located and evaluated on the ground, the report sheet should be filled out as completely as possible. Comments by inspectors regarding the utility of this method for wetland surveillance will, in part, constitute the basis for evaluation of its operational potential and aid in the re-shaping of product format if necessary. A sample report sheet is attached for reference. Any additional comments concerning the suitability of this product if routinely delivered to the NJDEP will be welcomed.

^{1/} Division of Marine Services and other agencies.

This report sheet is intended as a convenient means of documenting the utility of ERTS-derived wetlands surveillance data and for improving the format for its presentation.

COASTAL ZONE SURVEILLANCE REPORT SHEET

EARTH SATELLITE USE

LOCATION/DESCRIPTION

Photoquad name (USGS 7 1/2' map sheet):

General Location:

Calendar Date When Change Detected:

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION USE

FIELD INSPECTION REPORT

Date Visited:

Total Time Required for Travel and Evaluation:

(Starting point:)

Problems Encountered Reaching Area (describe):

Nature of Disturbance:

Person, Agent, or Company Responsible:

(Permit: ☐ yes ☐ no)
Source:

Area Affected, Acres (estimate):

Obvious Environmental Impacts of Disturbance:

Other Comments, Observations:

UTILITY EVALUATION

What improvements does this method offer over current procedures (e.g., time saved, more changes observed, etc.)?

What inadequacies limited its usefulness (inaccurate location of disturbances on photoquads, poor timing of notification, etc.)?

Describe utility of this technique for operational (e.g., day-to-day wetlands inspection functions:

So that you may be contacted for further evaluation of this technique, please provide the following information:

NAME: _____

ADDRESS: _____

TELEPHONE: _____


Please list any other persons involved in the use of this product. Feel free to have them attach or add comments.

APPENDIX E
TASK STATUS REPORT

APPENDIX E

TASK STATUS REPORT

Contract NAS5-21765

 = Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE I			
3.1.1	Determine existence of Pre-ERTS imagery for analysis	Completed 10/1/72	Visits were made to NASA MSC (Earth Resources Aircraft Data Bank) at Houston, Texas. A catalog of aircraft imagery has been prepared and delivered to NJDEP for use by state offices.
3.1.2	Assemble ERTS Data Analysis Equipment at NJDEP	Completed 2/1/73	The NJDEP ERTS data analysis facility at the Trenton, New Jersey Headquarters is operational. Basic image analysis equipments are available for ERTS investigators.
3.1.3	Analyze Pre-ERTS imagery set as a demonstration of technique	Completed 10/1/72	ERTS-1, Apollo, and aircraft imagery and their analysis were used to brief NJDEP officials. A manual for reference by state representatives was prepared and distributed.
3.1.4	Organize and conduct preliminary briefing with NJDEP	Completed 10/5/72	Briefing was held at NJDEP to demonstrate remote sensing techniques and possible products to be developed from ERTS. A manual for reference by state representatives was prepared and distributed.
3.1.5	Select candidate test sites	Completed 11/5/72	The Northern New Jersey Shore will be the primary test site with secondary test sites to be studied as NJDEP interest, or environmental problems arise.
3.1.6	Collect and organize existing ground truth data	Completed 12/1/72	A bibliography has been prepared. Collection of pertinent ground truth will continue throughout experiment. These data will be delivered to NJDEP.

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TASK STATUS REPORT

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= Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE I			
3.1.7	Perform reconnaissance of test area	Completed 2/15/73	EarthSat field-checked the northern New Jersey test site in February, 1973. In addition, a reconnaissance of the entire test area was made subsequent to studies conducted at the northern New Jersey test site. EarthSat suggests a modification to this task. In the future, a phone call will be made directly to the DEP advising them of EarthSat's intention to conduct field checking. This will be followed by a brief written communication to document the timing and content of the field exercise.
3.1.8	Develop final interview plan and conduct interviews	Completed 12/10/72	Interviews with key personnel in early December have led to initial plans for information products. Subsequent briefings after initial products are prepared will be needed. EarthSat will work closely with NJDEP in using the products.
3.1.9	Prepare ground truth collection plan	Completed 3/1/73	A multi-agency cooperative ground truth effort was planned for the period April 6-13, 1973.
3.1.10	Instrument test sites	Completed 4/7/73	Instrumentation (current meters, transmissometer, spectroradiometers, temperature recorders, PRT-5, tide gauge, etc.) was initiated in late March 1973 and was completed for the Northern Test area on April 7, 1973.
3.1.11	Prepare aerial survey plan	Completed 4/7/73	Five aircraft collected supplementary data over test site during ground survey effort on April 7, 1973; the NASA JSC C-130, NASA

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TASK	HEADING	STATUS	COMMENTS
PHASE I			
			Wallops C-54, University of Michigan C-47, and two helicopters.
3.1.12	Collect ground truth data	Completed 4/7/73	Preliminary field sampling was accomplished during reconnaissance survey and extensive sampling was completed during the April 7, 1973 effort.
3.1.13	NJDEP shall assemble equipments specified in 3.1.9 at (Toms River Facility)	Completed 4/7/73	NJDEP personnel and equipments were made available and used during April 7, 1973 ground survey effort. Personnel and equipments were coordinated from Monmouth Beach Marine Police Station.
3.1.14	Prepare line base maps for test area using simulated ERTS imagery	Completed 5/1/73	The production of line maps as designated in contract are unnecessary because all of the specified information is available on the USGS 7-1/2 minute quadrangle sheets and NOS and Naval Oceanographic Office nautical charts.
3.1.15	Use simulated ERTS imagery for candidate base maps	Completed 6/30/73	A folio of candidate ERTS-1 products has been assembled. The folio includes analytical maps for shore protection planning, ocean outfall placement, and effects of barge-dumped waste disposal. NOTE: ERTS imagery was available and there was no need to simulate it.
3.1.16	Develop and conduct Preliminary Cost-Benefits Analysis	Completed 6/15/73	The method's package for assessing and documenting benefits has been established. Two alternative methods for quantifying benefits were discussed with NJDEP (histori-

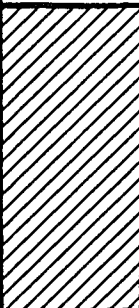
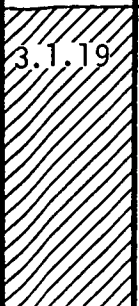
APPENDIX E

TASK STATUS REPORT

Contract NAS5-21765



= Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE I			
			cal and future savings) and a decision to proceed on projection of future savings has been accepted. The quantification of benefits will be directed to four candidate areas: shore protection, ocean outfalls, navigation channels, and waste disposal.
3.1.17	Brief NJDEP on use of candidate information products	Planned for 7/9-13/73	Following approval of the Principal Investigator, DEP personnel will be briefed on utilizing the ERTS information products as well as methods for assessing benefits. This briefing has been scheduled to take place during the week July 9-13, 1973. It is anticipated that a close interaction between EarthSat and DEP personnel will occur throughout the remainder of the program so as to facilitate full product utilization to various Department offices, EarthSat personnel will have available the small scale ERTS imagery that was used to develop those products. DEP personnel will be advised concerning procedures used for the analysis of this imagery.
3.1.18	Establish letter contacts with other States	Pending	
	3.1.19 Prepare plan for analysis of ERTS imagery	Completed 1-/1/72	Due to compression of Phase I, initial analysis plan for ERTS Imagery was established during initial briefings with NJDEP.

APPENDIX E

TASK STATUS REPORT

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= Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE II			
3.2.1	First-look analysis of first imagery	Completed 9/29/72	First-look analysis documented in first NASA progress report.
3.2.2	Analyze all ERTS imagery during Phase II	Completed 4/30/73	EarthSat has analyzed all ERTS-1 imagery as received and is in the process of developing information products. Tasks 3.1.15 and 3.2.2 are essentially the same because of the early receipt of ERTS-1 imagery. As a matter of routine, all scientific observations related to coastal processes made during ERTS-1 imagery analysis are documented on EarthSat forms which constitute permanent project records (Appendix A).
3.2.3	Analyze all ERTS imagery during Phase II by spectral band	Completed 4/30/73	All ERTS imagery is routinely analyzed by spectral band. These analyses have been referenced in previous progress reports and are part of a continuing program of image analysis. The usefulness of each spectral band (for seasons to date) has been determined and will be summarized in the First-Look Data Analysis Report. Judgements as to the usefulness of each spectral band were documented for NJDEP in October, 1972 at the initial briefing session.
3.2.4	Map coastal land-forms and outline the wetlands	Completed 3/1/73	Maps showing the outline of New Jersey wetlands as well as principal coastal ecozones (as judged from ERTS imagery) have been prepared and were delivered to NJDEP in July, 1973.

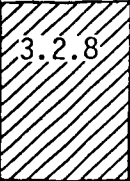
APPENDIX E

TASK STATUS REPORT

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= Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE II			
3.2.5	Use optical analysis equipment, and enhancement techniques in analysis of ERTS imagery	Underway	This is a continuing Task and will be underway throughout the experiment. Equipment includes, I ² S Digicol, I ² S Addcol, Bausch & Lomb ZTS, MacBeth Densitometer, etc.
3.2.6	Review and finalize information distribution with NJDEP	Underway	A flow diagram has been prepared (Figure 1) as a convenient visual reference to describe the ERTS information products distribution system. The relationship of each product to study objectives and a schedule for distribution of information products within the Department is presented. It is anticipated that the distribution system will be continually updated as new Department needs and products evolve.
3.2.7	Distribution of information products within NJDEP according to approved schedule.	Underway	Information products shall be distributed through the Principal Investigator, who will ensure that the necessary responses from Department personnel are obtained. EarthSat shall keep the Department informed of any difficulties in acquiring supporting data and of the results of product evaluation by NJDEP personnel. As specified in Task 3.1.8, close interaction between Department and EarthSat personnel is anticipated as a continuing function for the duration of the experiment.
 3.2.8	Prepare preliminary data analysis report at completion of Phase II	Completed 4/20/73	EarthSat has prepared a preliminary data analysis report which details analytical results through May 15, 1973 summarizes the utility of each ERTS band for coastal

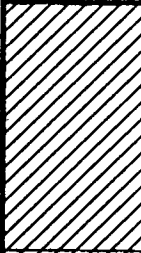
APPENDIX E

TASK STATUS REPORT

Contract NAS5-21765



= Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE II			
			studies, and includes copies of specific experimental analyses which have been conducted. Some results have already been reported in a paper presented at the NASA Goddard Symposium on Significant ERTS-1 Results.
3.2.9	Prepare a revised data analysis plan for Phase III	Completed 5/1/73	The revised Data Analysis Plan has been submitted.
3.2.10	Preliminary data analysis report and revised data analysis plan sent to NASA	Completed 6/1/73	
3.2.11	Finalize format and content of information products package for Phase III	Underway	Most of ERTS information products developed as a result of Department needs, respond to a one-time-only need and/or an immediate response, e.g., oil spills or pollution of coastal waterways and beaches, etc. Routine (repetitive) deliverables will include dredge spoil disposal and coastal surveillance maps prepared for NJDEP field inspectors. It is unlikely that rapid changes will occur in all of the information products delivered to NJDEP as was originally anticipated. The scale, format, or content of repetitively utilized products is subject to change.

APPENDIX E

TASK STATUS REPORT

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= Completed Tasks

TASK	HEADING	STATUS	COMMENTS
PHASE III			
3.3.2	Modify data analysis procedures	Pending	
3.3.3	Distribute final information products on a routine basis	Pending	All ERTS data, collateral aircraft data, and ground truth data received during the investigation will be analyzed to the extent necessary to prepare practical information products. Additional field observations will be required in the conduct of this task.
3.3.4	Work closely with NJDEP to best apply and distribute information products and document benefits derived thereof	Pending	The requirements of this task are basic to the investigation and are being met by EarthSat as the program proceeds.
4.3	Prepare final report	Underway	Sections of the final report are being written as the experiment progresses.
4.4	Prepare a program for continuing ERTS applications within New Jersey	Pending	
4.5	Prepare coastal states briefing package	Pending	

APPENDIX F
ERTS DESCRIPTOR FORM

DATE June 30, 1973PRINCIPAL INVESTIGATOR Roland S. Yunghans

GSFC _____

ORGANIZATION New Jersey Department of Environmental
Protection

NDPP USE ONLY

D. _____
N. _____
ID. _____

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Coastal Water	Pollution	Coastal Landform	
1133-15080-7	X	X	X	Coastline
1133-15135-7	X		X	Barrier Beach
1133-15141-7	X		X	Salt Marsh
1168-15074	X		X	
1168-15081				Clouds
1169-15132				Clouds
1169-15135				Clouds
1186-15075	X	X	X	Back Bay
1187-15133-7	X	X	X	Estuary
1187-15140-4	X		X	Silt
1204-15081-5	X		X	Coastal Current
1204-15083-5	X		X	Coastal Current
1205-15135-5	X		X	Estuary
1205-15141	X		X	Coastal Current
1222-15082	X		X	
1222-15084				
1240-15082-5	X		X	Estuary, Silt
1240-15085-5	X		X	Back Bay, Silt
1258-15082-5	X	X	X	Estuary, Silt

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADINGS NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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BLDG 23 ROOM E-113
NASA GSFC
GREENBELT, MD. 20771
301-982-5405